

## Developing a Learning Model to Promote the Skills of Analytical Thinking

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### Article Info

#### Article history:

Received Oct 27, 2017

Revised Jan 14, 2018

Accepted Apr 21, 2018

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#### Keywords:

Analytical thinking

ICAE model

Learning

Science

Skills

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### ABSTRACT

This research is aimed at developing a learning model that encourages the skills of analytical thinking in science. The method used is research and development. The result is the ICAE (Incubation, Collection of data, Analysis, and Evaluation) model that promotes analytical thinking skills. Results of normalized gain tests show that the gain score is 0.28, which indicates that the ICAE learning model positively affects students' analytical thinking, even though still within the lower category. The ICAE model also promotes the skills of analytical thinking in science and it has gained positive response from students.

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## 1. INTRODUCTION

Science learning allows students to apply scientific concepts and higher level thinking and encourages them to be aware of and care about the environment. Rote learning is not suitable for the teaching of science [1], [2]. Learning must foster the mastery of thinking skills and provide space for the development of social-emotional skills [3], [4]. Learning must serve as a catalyst for change and create situations or contexts that help students actively delve into science materials [5].

The twenty-first century learning emphasizes skills or abilities. Skills are automatically mastered by the way students learn and their style of learning [6], [7]. This twenty-first century learning skill are of some major components like learning and thinking skills, being technology savvy, and leadership skills (creativity, ethics, product-oriented). Science learning must cater to the students' need to learn those skills [8], [9].

Based on the report by McKinsey Global Institute in "Indonesia Today" and some excerpt from the Ministry of Education and Culture in Indonesia, only 5 percent of Indonesian students master the skills of analytical thinking. Most of the other students are only at the level of knowing Problems in science require analytical skills to be solved. This means low analytical thinking skills results in low lesson mastery. Junior high school students may still adopt the way of thinking from their elementary school years. They are still in the stage of transition. Therefore, there needs to be preparation and conditioning to promote analytical thinking among them, especially in science [10], [11].

This research aims to develop a learning model that encourages junior high school students to master analytical thinking in science. The model is based on the 21st-century learning paradigm, which is based on analytical thinking [12], [13].

### 1.1 Analytical Thinking Skills

Analytical thinking is a process of thinking that leads us to a better decision. First, we use the process of creative thinking by leafing through possible options for the problem we are dealing with, and then we use the process of analytical thinking to come up with better alternative solutions. The fundamentals of analytical thinking are to push us to have alternative options, and then gradually focuses more on the best of those alternatives.

The steps involved in analytical thinking include testing a question or evidence using standard objectives, looking through to the bottom of it, and then considering and deciding on a logical option. We have to think creatively to solve problems, but we also need to be analytical to decide which one of those creative options is the best. A systematic framework is required for analytical thinking, as this allows the faster decision for a solution. One of the systematic and scientific frameworks in analytical thinking is the problem-hypothesis-facts-analysis-solution model. According to Glass & Holyoak [2], thinking is a process that results in mental representation via information transformation involving complex interactions of mental attributes such as valuation, abstraction, logic, imagination, and problem-solving. Thinking is a person's mental ability that can be categorized into logical, analytical, systematic, critical, and creative [11].

According to [13] analytical thinking is the ability to know the details or explain a problem into smaller components and to understand the interrelationships among those components. This is also supported by [15] who states that analysis as a purpose has three subcategories of derivation; analysis of components, analysis of interrelationships, and analysis of principle organizations.

An analysis is meant to classify elements into orderly parts in order to figure out as to how those elements are made and how they are related. Other than that, analytical thinking also means a person's ability to classify factors and determine the relationships and the true cause of an event [16]. Analytical thinking skills are also referred to as critical thinking skills. A person with this skills can analyze and evaluate ideas very well. Every person, even the most creative individual, does have good and bad ideas. A creative individual, on the other hand, uses his/her ability to determine the implications of his/her creative ideas [17], [18].

### 1.2 Developing a Model of Analytical Thinking Learning

Analytical thinking is required in the teaching of science. Analytical thinking skills is a strong way of understanding a defined element of the situation. It is an ability to analyze facts and ideas, and come up with the smart solution for a problem, data analysis, and use of information [19], [20].

According to the theory of learning, Gestalt (1890) in [20], when a person is looking for a way to solve a problem, he/she will have difficulties concerning solutions and uncertainties that he/she will keep on trying to find the best answer. This may go on and on without a proper solution being found. In order to find the best and most proper solution, a person needs a partner in a collaborative attempt. This is in line with a theory from [21] which states that the process of developing higher thinking skills depends on social interactions and the construction of higher cognitive ability.

One of the learning models that suit the theory of cognitive and social constructivism that aims to develop analytical thinking skills is the inquiry learning model. In this model, learning is centered on students as they collaborate problem-solving and reflection on certain experiences. An inquiry is a process used by scientists in their research and this is beneficial for students of science in developing their scientific skills. It is a learning strategy that can be used to teach students to think and learn scientifically [22]. Inquiry learning allows students to develop scientific understanding [23], [24]. A research by [8] concludes that inquiry-based learning promotes both cognitive and analytical thinking in students, while students also positively respond to this method by reporting more satisfaction in learning.

The learning model developed in this research is called ICAE. This stems from the inquiry learning model. Modifying the steps in the inquiry learning model will improve its efficacy and help find the most suitable model to promote analytical thinking skills for junior high school students as they learn science.

## 2. RESEARCH METHOD

This study is research and development in nature. The procedures include; 1) finding and collecting relevant information to development; 2) planning for the components to develop, outlining the purpose, determining activity sequence, and making measuring scales (research instrument); 3) developing an initial design as a model; 4) validating conceptual models with the help of experts or practitioners; 5) conducting a limited trial (stage I) against the initial model; 6) revising the initial model, based on trials and data analysis; 7) conducting a large-scale trial (stage II); 8) carrying out a final revision or model refinement, if it is deemed by the researchers and/or the other related parties that the results from the model are not yet satisfying; and 9) making a research report and disseminating it [25].

The subjects of this research were first graders of some junior high schools in Central Java, i.e., from SMP 33 Semarang, SMP 8 Semarang, SMP 2 Songgom Brebes, SMP 3 Mranggen Demak, SMP 3 Dawe Kudus, and SMP 2 Gabus Pati. Data were collected using questionnaires, observations, tests, and documentation. Two analyses were then carried out. First, effectiveness analyses using normalized gain test, and second, descriptive analysis of supporting data.

### 3. RESULTS AND ANALYSIS

The learning model developed in this research is called the ICAE Model, with syntax as follows:

- a. Phase 1 (problem incubation), in which teachers' activities cover: organizing the class by dividing students into heterogeneous groups, and preparing lesson logistics; stating the purpose of the lesson and motivating students by presenting a problem; and providing guidance for problem identification and planning for data search.
- b. Phase 2 (collection of data), in which teachers' activities include: guiding students to collaborate in their search for information and research for answering problems.
- c. Phase 3 (analysis), in which teachers' activities include: creating a condition to help students make analyses and present their findings.
- d. Phase 4 (evaluation), in which teachers' activities include: guiding and facilitating students in evaluating their analyses.

The syntax in the ICAE model is supported by the theory of ARCS (Attention, Relevance, Confidence, and Satisfaction). This theory says that in order to instill curiosity in the lesson, students must pay attention [26], [4]. The ICAE model is also supported by the learning theories of cognitive constructivism and social constructivism [27].

A limited trial was carried out against grade VII F students of SMP 33 Semarang on the material of Simple Instrument. The design used was one group pretest and posttest. This trial was aimed at figuring out the level of analytical thinking improvement after the ICAE learning model was implemented.

Table 1. Pre-test Result of a Limited Trial

No.	Interval	Frequency	
		Absolute	Relative (%)
1	38 – 46	10	32.26
2	47 – 55	1	3.23
3	55 – 63	6	19.35
4	64 – 72	4	12.90
5	73 – 81	8	25.81
6	82 – 90	2	6.45
Number		31	100

Table 2. The post-test Result of a Limited Trial

No.	Interval	Frequency	
		Absolute	Relative (%)
1	46 - 54	3	9.68
2	55 - 63	8	25.81
3	64 - 72	4	12.90
4	73 - 81	6	19.35
5	82 - 90	8	25.81
6	90 - 98	2	6.45
Number		31	100

Results of both pretest and posttest were then undergone further tested using the normalized gain test. The latter results show that the gain score is 0.28, which means that the ICAE model learning does affect students' analytical thinking, but still within the lower category.

Implementation of learning model was observed using observation sheets. A good category implementation has a value of 79.17%. There were still a few drawbacks in the implementation of ICAE learning by teachers in the first meeting, due to: 1) guidance was not detailed enough that students have difficulties in understanding problems and hence planning for data collection; 2) guidance were not graded; and 3) guidance was not directed toward evaluation and lacked details. These findings later served as points of improvements for the second meeting. Therefore, no significant hindrances were found.

A wider trial was implemented in SMP 8 Semarang, SMP 2 Songgom Brebes, SMP 3 Mranggen Demak, SMP 2 Dawe Kudus, and SMP 2 Gabus Pati. Results are shown in Table 3 with the resulting subsequent analyses are given in Table 4.

Table 3. The Result of Wider Trials

Value	SMP 8 Smg		SMP 2 Songgom		SMP 3 Mranggen		SMP 3 Dawe		SMP 2 Gabus	
	pre	post	pre	post	pre	Post	pre	Post	pre	post
10-16	5		2							4
17-23	16	1	9							7
24-30	11	5	11				3			5
31-37	4	12	8	2	5					5
38-44		5	8	5	5		4	1		2
45-51		7	1	4	9		4	4		
52-58		2		3	0		2			
59-65		3		2	12	12	6			
66-72		1		8	1	8	1	2		6
73-79				7		4	1	3		7
80-86				8		8		4		7
87-93								1		3
94-100								6		
Number	36	36	39	39	32	32	21	21	23	23
Average	21.42	39.51	28.56	62.69	50.00	71.25	52.75	78.25	26.27	77.45

Table 4. Improvement of analytical thinking.

	SMP 8 Smg	SMP 2 Songgom	SMP 3 Mranggen	SMP 3 Dawe	SMP 2 Gabus
Pretest	21.43	28.56	50.00	52.75	26.27
Posttest	39.51	62.70	71.25	78.25	77.45
Gain	0.23	0.48	0.43	0.54	0.69
Category	Low	Medium	Medium	Medium	Medium

Table 5. Recap of subject responses.

No.	Response Indicator	%
1	ICAE Model is useful in science learning	96.03
2	ICAE Model stimulates new ideas	96.69
3	ICAE Model enhances science learning skills	99.34
4	ICAE Model helps understands science	96.69
5	ICAE Model encourages active learning	96.03
6	ICAE Model provides motivation	99.34
7	ICAE Model promotes analytical thinking	98.01

Data show that the ICAE model designed to promote analytical thinking is actually effective. The syntax it provides helps students construct science in their minds both by themselves and via interactions with fellow students and teachers. This is in line with learning constructivism, which states that learning is a process undergone by individuals who actively seek to build knowledge based on his/her personal experience whilst interacting with others and the environment. According to [27], the theory of constructivism learning has two facets; cognitive and social. Cognitive constructivism deals with how individuals frame knowledge in their minds, whereas social constructivism relates to how individuals interact with others to gain knowledge.

Vygotsky's view on social constructivism also mentions cognitive apprenticeship. Cognitive apprenticeship concerns the process in which students gradually acquire skills from interactions with experts, either grownups or their peers, who are more advanced in their knowledge than they already are [28].

In the ICAE model when trying to solve problems, students learn from apprenticeship, where they have to cooperate with the teacher or the other students who are more skillful in the process of problem incubation. The teacher provides examples, feedbacks, and gradually leads students to the process of problem-solving. The environment facilitates students to gather initial knowledge concerning the issues to be solved, conduct analytical thinking activities, and allow students to experience the scientific process of implementing scientific methods.

Hence, the ICAE model is a good alternative in the teaching of science. The ICAE model has been proven to be effective in promoting students' analytical thinking skills. Response from the students is also positive. They agree and support the implementation of the ICAE model. Every student from all schools who was the subject of this research likes the idea of implementing the ICAE model in their science classes. They said that the ICAE model is very useful in learning science, promotes idea generation, helps improving science skills, helps understanding lesson materials, encourages active learning, motivates students, and facilitate

analytical thinking. Therefore, it can be inferred that students positively respond to science learning using the ICAE model.

#### 4. CONCLUSION

Results and the subsequent discussion led to the following conclusions:

- a. A model that promotes students' analytical thinking skills has been developed. The model is called ICAE that includes the syntax of problem incubation, the collection of data, analysis, and evaluation.
- b. The ICAE model is very effective to improve the analytical thinking skills among junior high school students, especially in the teaching of science.
- c. Students positively respond to the teaching of science using the ICAE model.

The effects of instructional science learning using the ICAE model are : (a) students know, understand, apply, and analyze scientific concepts based on their own experiences; (b) students are able to apply scientific knowledge to solve problems; (c) students have the ability to collect data via scientific methods; (d) students have the ability to analyze data.

The side effects of science learning using the ICAE model are: (a) students are highly motivated to learn; (b) students have collaborative skills to work with their peers; (c) students respect they way their peers think and their opinions; (d) students are independent and responsible for their own work.

#### ACKNOWLEDGMENTS

The writers wish to thank The Ministry of Research, Technology, and Higher Education of Indonesia for the financial support it provides for this research.

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