

Higher Order Thinking Skill in Physics; A Sistimatical Review

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Abstrack

This article aims to discuss the concept of higher order thinking skill which is specific for physics in senior high school. This article is also offer learning model and assessment tools which can be used to increase the ability of high order thinking skill in physics, specific to senior high school students. This article used sistematic review model which use five steps model from Khalid, such as framing the question, identifying relevant work (relevan publication), assessing the quality of study, summarizing the evidence, interpreting the finding. The journal used is taken from Elsevier, Springer, IEEE, Wiley Open Access, and Taylor & Francis. The characteristics of higher order thinking skill is divided into three paradigms. The first is general thinking which is consist of scholarship thinking, career thinking and ekstrakurricular thinking. Second is skill spesifik thinking such as transfer, critical thinking and problem solving. Third is disipline spesifik thinking which consist of reasoning, mathematical thinking and problem solving. Learning model which can be applied such as problem based learning, Inquiry-based learning, Contex based learning and Active learning. Tools which can be used for assesment such as multiple choice. Stimulus such as graph, flowchart, pictures, quantitative model, case study and kontekstual problem. The concept of learning model, tools and stimulus to assess the higher order thinking skill which is offered in this article is expected to help the teacher to develop the students' ability for higher order thinking skill in physics.

Keywords : HOTS, Physics, Concept, Learning, Assessment, Systimatical Review

1. Introduction

Higher Order Thinking is often linked with Bloom's Taxonomy [1-3] mainly for the highest three level of thinking in Bloom's Taxonomy [4], such as synthesis, analysis and evaluation or appropriate with Anderson and Krathwool's revision [5] namely analysis, evaluation and creation. Most of teachers or educators are stucked with these three kinds of thinking when making Higher Order Thinking level of question [6-8]. However, there are more enough types of thinking including in Higher Order Thinking category, for instance comprehensive thinking, deep thinking, rational thinking, critical thinking, logical thinking, reflective thinking, metacognitive, creative, and many others [7, 9]. Meanwhile, there are many experts clarifying the Higher Order Thinking types like Brookhart adding critical thinking , reasoning and problem solving in Higher Order

Thinking Skill category [1, 10], While Martano known as his thirteen ideas level of thinking [11], and King [9] with critical, logic, reflective, metacognitive thinking and creative as well as some others experts given their ideas related to the types of thinking which including to Higher Order Thinking level [12].

Most of experts only provide the basic of the Higher Order Thinking types in general [7]. In a knowledge field, we are not always be able to explore all of those thinking types. It needed to discovered the Higher Order Thinking level which is appropriate with the character and the fundamental from each knowledge field. Higher Order Thinking can be placed into three paradigms [7, 13], (1) non-specific dicipline and non- specific skill, (2) non-specific disciplines and specific skills and (3) specific disipline and specific skills. Those paradigms strengthen that currently Higher Order Thingking level is actually still general so that it need to be discovered more Higher Order Thinking which is more specific appropriate with the characteristics of a knowledge field, for example appropriating with physics's charactheriaticts.

Improving students' ability in Higher Order Thinking can be done in two ways, by appropriating learning model and assessment giving [2, 14-17]. Suitable Learning model and assesment can encourage students to learn with Higher Order Thinking. Generally, there still many teachers who have not been able yet to design learning model and giving assesment by using Higher Order Thinking based-question [8, 18-20]. Even though, they have to be aware that learning and assesment using Higher Order Thinking must be applied in learning process to prepare the students' ability in facing competition in 21st century [3, 21, 22]. Based on this fact, teachers should have an ability to design and develop the Higher Order Thinking level question. On the other hand, it means that if their ability is on low level in designing Higher Order Thinking level question, it will give a bad impact on the quality of students' learning process and question made [23]. Finally, it shows that how important the teachers' action related to developing students' scientifics ideas and their reflective thinking.

However, implementing and developing Higher Order Thinking level question can be said so difficult enough, but it doesn't mean can not be learnt. As Jensen [19] state that in writing test with Higher Order Thinking level is a challenging task for teachers. So that teachers should improved their ability to help students gaining their deep understanding toward the materials thought. According to this reason, it shows that how important Higher Order Thinking level applied in learning procces and assesment. Teachers are required to have skill in construct the test in Higher Order Thinking level or at least there should be guidance for them related to learning and assesment model which can be used in developing students' Higher Order Thinking skill. Based on the result study and analysis above, this article is focused on; what is Higher Order Thinking Skill concept of physics for Senior high School students.

3. Material & Methodology

This study including in sistematical review by using five steps model [24]. The first step is framing the question, second is identifying relevant work (relevant publication), third is assessing the quality of study, fourth is summerizing the evidence, fifth is interpreting the finding. The analyzing done by sistematical how to search in six based-data of scientific science followed by critical analysis. Detail searching used in this research including: higher order thinking, scholarship thinking, carieer thinking, extracurricular thinking. The data base used is as follows;

Tabel 1. List of Journals and number of articles

Journal	URL	Total Results	Primary Selection	Final Selection
IEEEExplore, Elsevier, Springer, WOC, Taylor & Francis	http://ieeexplore.ieee.org/Xplore/home.jsp	502	150	98
	http://www.sciencedirect.com/			
	https://link.springer.com/			
	http://www.wileyopenaccess.com/view/journals.html			
	http://www.tandfonline.com/openaccess/openjournals			

4. Results & Discussion

This article consist of three main part, namely discussing higher Order Thinking concept of physics, leraning model to develop Higher Order Thinking ability.

Table 2. List of literature for concept

Componen	Article
General thinking	[1, 6, 7, 21, 22, 25-37]
Spesifik skill thinking	[1, 7, 21, 38-49]
Spesifik disipline thinking	[7, 18, 50-58]

4.1 General Thinking Developing from Wang Framework

The paradigm of thinking “ non specific science and non specific competence” or now it called general thinking has been discussed in several educational literatures [7, 28, 37, 59, 60]. General thinking become the essential level of thinking for students for long term planning. Wang [7] explain there are three kinds of Higher Order Thinking level in this paradigm, including career thinking, scholarship thinking and extra-curricular thinking. Those three thinking level have different scope. Career thinking more emphasize on personal competence to design the future, reflect and continue the vision, and able to make a long term goal [61]. Career thinking lead on thinking about identity and personal identity [62], as what is the thing that important for me? Which is way appropriate for me? How can i adapt myself?Wrong perspective related to career thinking can obstruct problem solving and career in future [63]. Students’ competence in making future target is required.

Scholarship thinking lead on students’ ability to improve their academic competence, the ability to evaluate learning process, finding slot between what they have learnt with what should be thought [7]. By the other word, scholarship thinking is an ability owned by students to understanding learning process occuring. So it can be assumed as academic thinking. This ability can be assumed as a short-term thinking skill (in one leraning cycle) which is the ability to understanding the process occuring in school. Diffrent with scholarship thinking, extra-curricular thinking lead to the belief that to gain knowledge not only from school, but also the knowledge can originated from daily experience.

4.2 Skill thinking by Brookhart framework

The second paradigm is specific thinking skill in this research use thinking level which is proposed by Brookhart [1] such as logic and reasoning thinking, judgement and critical thinking, problem solving, creative thinking, transfer (analysis, evaluation, creation). Brookhart's thinking level chosen because its wider scope than others. Specifically, the taxonomy from Brookhart can be pursued to the three levels of thinking, if we refer to the definition of HOTS from Brookhart [15, 64, 65], such as transfer, critical thinking and problem solving.

Transfer consist of analysis, evaluation, and creation. Analyzing covers with the ability to solve an unit to be some parts and determining how its parts are connected each other or part itself with the entirely [5]. Evaluation is someone's ability to make consideration toward one condition, value and idea. Another definition from Anderson and Krathwohl [5], that evaluation is an ability to do judgement based on the criteria and particular standard. The criteria which often used is determining the quality, effectiveness, efficiency, and consistency, while the standard is used in determining both quality and quantity. Dadan Rosana (2014:94) reveal that creation is someone's ability in combining various informations and developing it to become something new. In other hand, Anderson and Krathwohl (2001:128) reveal that create is a process compiling the elements to be totality which is coherent and functional.

According to Dadan Rosana (2014:380) critical thinking can be understood as a thinking ability in assessing an information before it becomes a mind and saved in memory. Beyer (1995) in Dadan Rosana (2014) offered the simplest definition "critical thinking means making a logic assessments." According to Beyer, critical thinking is a way of discipline thinking used by someone to evaluate the validity such as statement, idea, argument, research, and etc. Another point of view from Norris and Ennis in Brookhart (2010), states that "critical thinking in the sense of reasonable, reflective thinking focused on deciding what to believe or do". Critical thinking is considered as a reflective thinking focused on deciding what have to believed or done. In this case, "able to think" means students can apply wise assessment or create a reasoning critic.

Brookhart give the following definition related to the problem solving: *A student incurs a problem when the student wants to reach a specific outcome or goal but does not automatically recognize the proper path or solution to use to reach it. The problem to solve is how to reach the desired goal. Because a student cannot automatically recognize the proper way to reach the desired goal, she must use one or more higher-order thinking processes. These thinking processes are called problem solving [10].* Those are including remembering information, learning by understanding, evaluating idea critically, forming alternative creative, and communicating effectively.

Brookhart [1] claims that if teachers think about higher order thinking as a problem solving, they could set determining the learning goal to teach the students how to identify and solve problem at school and life. This case, not only involving problem solving which is set by the teacher but also solving a new problem defined by themselves, create a new thing as its solution. A wide definition from problem solving is the skill possible for someone to find a solution for problem which can not be solved by remembering.

4.3 Higher Order Thinking in Physics

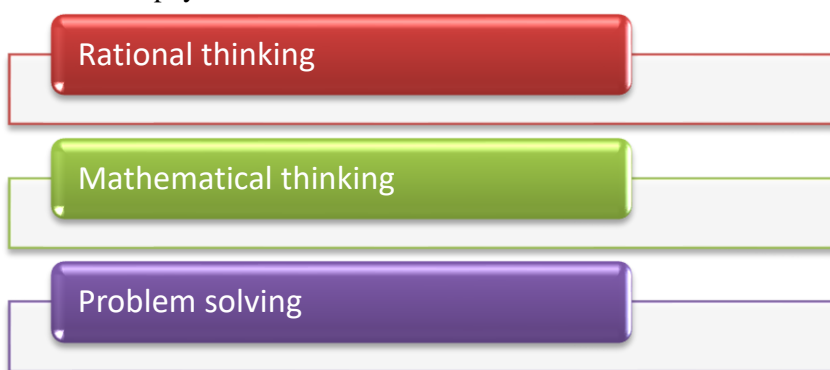
The third paradigm "specific scholarship and specific competence" or what we called as higher order thinking of physics. The level of thinking in this paradigm is based on the result of analyzing by researcher, by adapting between types of thinking of HOTS and the characteristic of physics. There are three levels of thinking used, such as rational thinking, Mathematical thinking, and problem solving. Those types of thinking used based on several reasons.;

- In physics learning, the knowledge about the concept, law and theory considered as an essential need. Students' ability in understanding the concept, law, and theory are

not only by memorizing the form, but more than that they can find when the concept applying, how its phenomenon, and how it can be applied in a real life. Therefore, rational thinking in physics can be done by asking the concept, its applied in real life or contextual problem in daily life.

- In physics, language used to explore the natural event is mathematical language. Therefore, mathematical thinking ability become a requirement to maximize the mastery of physics. If we are accustomed to use mathematical thinking, it can be developed thinking ability, the ability of logical thinking, analitic and systematic. The use of mathematics in physics in not only by simple calculating activity, but it is a complex matter. Communicating mathematics thinking in physics can be done by using symbol, table, diagram, and other media.

- Problem solving in physics learning demand mastering mathematics concept, reasoning, and mathematics competence to help students making creation in solving problem given, eventhough it can be done by mixing with material or concept with another relevant physics.



Picture 1. Higher Order Thinking Skill in Physics

4.3.1 Rational thinking

Rational thinking ability related to the goal achievement in real life [58, 66]. The main dimension from rational thinking ability including scientific thinking, probabilistic thinking, literate financial, practical figure, personal confidence [67, 68]. Rational thinking focus on contextual cases but currently learning by focusing attention in real life or around environment is still rarely done. Learning should be more contextual, taking example or daily life background.

The aim of teaching basically to equip students in order to be able to give a reasoning, reflecting, and making a right decision related to real life [14]. One of characteristics of educated people is they have a reason and making a right decision for themselves without encouraging from teacher or task [69]. Assessment become a point which is really required in higher order thinking ability such as assessing truth value of an event based on concept, source of credibility, the truth of the concept in physics or questions related to science concept [18, 51, 70]. In physics, types of rational thinking is really required to understanding the fundamental, theory and concept of nature. Physics related to the theory, concept, law and rule. to understanding those things, it needs to built logical rational. In developing this rational skill can be done by giving learning which explore the science concept and using assesment by using logic. The science concept to build the logic has to be related to daily life activities.

Rational thinking ability in physics contains meaning as a thinking process related to scientific thinking ability, probabilistic, understanding concept, logic and reasoning used to analyze an event or occurrence in real life. Rational thinking ability is required in learning physics. Several taxonomies which probably relevant with rational thinking such as reasoning and critical thinking.

4.3.2 Mathematical thinking

Mathematic is a basic science which is really required as a base for technology and modern knowledge. To mastering and creating the technology in the future required mastering strong mathematic since early stages. Basically, mathematic subject given to equip the learners with the logical thinking ability, analitic, sistrematic, critical, creative and the ability to cooperate, besides that, developing the ability by using mathematic in solving problem and communicating the idea by using symbol, table, diagram and other media.

One of the advantages we often point out is that mathematics practise someone to think logically. Mathematics gives a high skill to someone in abstraction power, analyzing the problem and reasoning logic. Therefore, mathematics useful to help in reviewing around the nature, so it can be developed become a technology for human welfare. Trend of science which is more quantitative , rest in mathematics which is finally make mathematics develop fast.

In physics, language used to explore the natural event is mathematic language. Mathematics can be assumed as a support to make it easy to understanding physics. Mathematic has an important role in physics. Physics subject is one of the sciences which talk about the phenomenon and natural behavior, as long as it can be observed by human. The way to explore is not only by quantitative but also qualitative.

Mathematics as a level of thinking in physics has a meaning as students' skill in abstraction power, analysis problem and reasoning logic in problem solving and communicating the idea by using number, symbol, table, diagram, and other media.

4.3.3 Problem solving

The higher level in cognitive dimation in physics subject is problem solving. Students can be said having problem solving thinking ability if they are able to find out the right solution in solving problem given. Problem solving in principle is a rule or order done by someone to solve the problem by basic knowledge concept which has been learnt before [55, 71]. The problem is a situation when individual want to do something but they do not know the action needed to get what they desired [51, 55, 72, 73].

Problem solution in physics subject demand the mastering material concept by students. Students can have a different way of working which appropriate with mastering the material related to the task given, or even they also can combine with the other physics material or concept which is relevant. Consequently, in problem solving thinking level, students are required mastering basic knowledge, reasoning and mathematical skill to help them in creating problem solving which is given (including critical thinking and creative thinking)..

The process of problem solving needs the series decision respectively, which each of them depend on the result preceding. Furthermore, Brainsford and Stgain in Brookhart [1] give five steps in problem solving process, namely 1) identifying the problem, 2) defining and representating the problem, 3) exploring solution strategy which most possible, 4) implementing solution, and 5) evaluating the result from the solution which has been done. The five steps can also apply in developing students' problem solving thinking skill.

5. Conclusion

Higher order thinking concept currently is still general, so it required to discovered the higher order thinking level appropriate with the character and the fundamental from each knowledge field, such as physics. This article also provide the guiding related to the learning model and assesment model which can be used in learning to improve higher thinking order skill in physics. Therefore, this article focus on defining the concept of

HOTS in physics for senior high school students, offering learning model which can be used to develop the ability of higher order thinking skill in physics, and providing stimulus and assessment tools that can be used to improve the students' higher order thinking skill based on the literature review.

The characteristics of HOTS are divided into three paradigms, such as 1) General Thinking consisting of scholarship thinking, career thinking and extra-curricular thinking, 2) Skill Specific Thinking, such as Transfer, critical thinking and problem solving, 3) discipline specific thinking including reasoning, mathematical thinking and problem solving. Learning model which can be applied such as problem based learning, inquiry based learning, context based learning and active learning. Tools which can be used for assessment such as multiple choice, description, wrongly-false, short field. Stimulus such as graph, flowchart, pictures, quantitative model, case study and contextual problem. The concept of learning model, tools and stimulus to assess the higher order thinking skill which is offered in this article is expected to help the teacher to develop the students' ability for higher order thinking skill in physics.

The concept of high-level thinking today is still general, so it needs to be dug up a high level of thinking that matches the character and essence of each field of science, such as physics. This article also provides guidance on learning models and assessment models that can be used in learning to improve HOTS Physics skills. Therefore, the focus of this article is to define the physics HOTS concept for high school students, offering a learning model that can be used to develop HOTS ability in Physics, and provide stimulus and assessment tools that can be used to improve students' HOTS capabilities based on the results of the literature review.

The characteristics of HOTS are divided into 3 paradigms, namely (1) General Thinking, consisting of scholarship thinking, career thinking and ekstrakurricular thinking (2) Thinking Specific Skills of Transfer, Critical Thinking and Problem Solving (3) Specific thinking discipline includes reasoning, mathematical thinking and problem solving. Learning models that can be applied such as problem-based learning, Inquiry-based learning, Context based learning and Active learning. Tools which can be used for assessment such as multiple choice, Description, wrongly false, short field. Stimulus such as graph, flowchart, pictures, quantitative model, case study and contextual problem. The concept of learning model, tools and stimulus to assess the higher order thinking skill in physics

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