Jurnal Pemikir Pendidikan (2016) 7: 1–18

THE DEVELOPMENT OF STUDENTS' CAPABILITIES IN HIGHER ORDER THINKING SKILL (HOTS) THROUGH SCIENCE EDUCATION

Amsah Arase, **Nurzatulshima Kamarudin**, & **Aminuddin Hassan**
Faculty of Educational Studies, Universiti Putra Malaysia
Serdang, Selangor

[1]biolifeam@gmail.com

ABSTRACT

The development of students' capabilities in Higher Order Thinking Skill (HOTS) is currently embraced as a very critical and important matter in the Malaysian schooling system. It needs a specific attention as the country lately has going through the transformation in the education sector specifically in the area of students' HOTS development. The teachings of HOTS need to be integrated in the subject syllabus purposefully in a well-planned effort to educate and train the students to think in a higher level manner to solve problems individually or cooperatively. Therefore, teachers have to move and shift their paradigm and practice from the traditional exam oriented classroom teaching into instructional practices that promote the skills. The literature review study reveals that teachers have lower capabilities and competencies in integrating and fostering thinking skills in teaching their subject matter. This paper examines the conceptual definition of HOTS generally in the various teachers' classroom setting and education level and to be specifically within the context of science lesson. Some of the key focuses mentioned are the approaches, strategies and model in teaching thinking skills. Recommendations are also made regarding the classroom practices in teaching HOTS in science lesson contexts. The implication of this paper lies for its possibilities to contribute to the source of reference for teaching HOTS that might be referred with.

Keywords: Higher order thinking skills, science, education, lesson, learning, teaching

INTRODUCTION

Malaysia currently has going through the transformation phase particularly in the country's vision to become a well-developed country on its own model. Thus, the education sector is highly hoped to be capable in producing the best quality of human capital for the country. Teacher is then highly required to be able shifting and enhancing students' intellectual capabilities and competitiveness as a preparation for the students to become a global industry player. The responsibility therefore lies in all education and school level particularly in the secondary school level where it is important for the students to be able to continuously develop skills and ability to learn actively through the activities of thinking, reasoning, decision making, problem solving and interpersonal competence (King et al., 1998). In the context of Malaysian Secondary Science education, one of the obvious and important focus of the curriculum is to enhance the students' capabilities in thinking skills as clearly explained in the Malaysian Science Curriculum (Malaysia Curriculum Development Centre, 2001). Those specific thinking skills are systematically framed in the Thinking Skill Thinking Strategy (TSTS) framework (Malaysia Curriculum Development Centre, 2001). All those stated thinking skills in TSTS framework is conceptualized as higher order thinking skills (HOTS) by King et al. (1998) which include creative thinking, critical thinking, logical thinking, reflective thinking and metacognitive. Definitely, teachers whom said to be the classroom facilitator need to facilitate the development of the skills through effective teaching strategies and supportive learning environment. As the needs of the country had changed towards a high quality human capital, so do the education sector. Schooling system needs to give more focus on the efforts on how the students best to acquire the necessary thinking skills for their survival in the rapid changes of the world. So, teachers need to ensure that their Science lessons should not only meaningful, interesting and meeting the current needs but it also has to be able in preparing the students for the future.

Despite acknowledging the importance of developing HOTS, the literature findings in Malaysia and other developing countries reveal the students decreasing ability in thinking skills, especially when the schooling system has overemphasized to master in particular subject content as compared to the process of attainment of the knowledge (Rosnani & Suhaila, 2003). There was a great appeal in Malaysia nationwide lately when the test scores on higher order tasks had declined especially in the Mathematics and Science standards according to the 2011 results of an international

benchmark; Trends in International Mathematics and Science Study (TIMSS). Malaysian students had dropped in test scores for both subjects for the 1999-2011 period. In another international education benchmark on higher order task; Programme for International Student

Assessment (PISA) 2012 edition, Malaysian students' Science scores saw a decline versus the older findings in 2009 edition. An important issue had arose; is the concept of HOTS still new to the teachers, or do students still not understand the meaning and concept of HOTS (Heong et al., 2011a; Heong et al., 2011b).

Therefore, the correct and innovative ways of instruction that emphasize and focusing on the development of students' HOTS through Science lesson is crucially to identify in the first place. As noted from the literature, the change from an instruction that emphasize on the mastery of content to an instruction that focus on the process of knowledge development is much depend on the teachers' pedagogical knowledge as well as their beliefs about the whole process of teaching and learning in the classroom (Zohar, 2006). To promote and develop students' HOTS, teachers must early well comprehend themselves with the particular specialized subject content knowledge and as a critical complementary, teachers also need to have the pedagogical content knowledge which is needed to purposefully develop students' HOTS (Barakh & Shakhman, 2008). According to Rajendran (2008), students who were taught to think well to solve problems were better suited for more complex problem solving than those who were not. He also mentioned that, the teaching of thinking skills could enhance students' academic achievement. Therefore, the teaching of HOTS in the context of Science lesson seems to be crucial and cannot be over looked. Furthermore, Heong et al. (2011) suggest that HOTS are teachable as well as learnable and all students should be given the right and opportunities to learn, develop and apply HOTS throughout their schooling period.

LITERATURE REVIEW

Conceptual Definition and Importance of Teaching the Higher Order Thinking Skills (HOTS)

Higher order thinking has been conceptualized for decades ago. It continuously and broadly defined by researchers and educators until recent times. The earlier conceptions of HOTS are initiated from the Bloom's Taxonomy of Educational Objectives (Bloom et al., 1956). In the cognitive domain of Bloom's Taxonomy, the levels of Knowledge and Comprehension were corresponded to lower order thinking and the rest of the levels; Application, Analysis, Synthesis and Evaluation were corresponded to higher order thinking. Anderson and Krathwohl (2001) who had made a revision on Bloom's Taxonomy had transformed the initial six 'noun' terms that determined the levels into 'verb' forms. In Bloom's Revised Taxonomy, Remembering, Understanding and Applying were categorised as lower order thinking while the rest Analysing, Evaluating and Creating were determined as higher order thinking. In addition, fundamental abilities of HOTS have different levels of complexity from kindergarten through grade 12 which can reflect students' cognitive development (NRC, 2000). In other words, level of individual thinking also have effect to educational level either low, moderate or high level of thinking.

Another early point of view from the literature regarding HOTS was explained by Resnick (1987). He characterized higher order thinking as non-algorithmic, complex, self-regulative, meaningful, and effortful. It also further explained that higher order thinking produce; multiple solutions and involved multiple criteria, uncertainty and nuanced judgement. According to Rajendran (2008), he explained higher order thinking as the expended use of the mind to meet new challenges which will occur when a question to be answered or problem to be solved could not be resolved by using the usual ways with the knowledge that previously learned. Another view from the local study had explained that HOTS involves information analysing effort to determine and evaluating the problem and further creating new applicable solutions (Chidozie et al., 2014). They also had explained that the persisting effort to develop students' HOTS is a direct factor of continuity of stimulating students to practice HOTS in completing their given task. In terms of teaching and learning, Minaili (2012) links HOTS with teacher's classroom setting. Teachers' classroom setting includes student arrangement in class, including during lectures, tutorials or in the laboratory and teaching strategies towards effective learning. Classroom setting supports the open

expression of ideas, provides active modeling of thinking processes, develops thinking skills, and motivates students to learn. Without it, students will not persist in higher level thinking processes.

In another literature findings, the conceptual definition of HOTS had been explained by King et al. (1998) as including all the thinking skills which are critical and creative thinking, logical and reflective thinking as well as the thinking about thinking; metacognitive. All those thinking skills will be initiated when a person is facing and handling a dilemma or to resolve unfamiliar questions, problems or situations. They further explain that HOTS are actually well developed from lower order thinking skills such as remembering, understanding and applying. The researchers also had claimed that they had conceptualised and defined HOTS consistently with recent time theories regarding the teaching and learning of HOTS even though there were many different frameworks used by other researchers and educators in describing HOTS and its teaching and acquisition. They had also mentioned that all the different frameworks of HOTS are under general agreement.

While different researchers and educators around the globe had defined HOTS in a similar regard for decades, there are still many other different version of HOTS definitions stated by researchers especially within their area of extensive research. Table 1 shows a brief summary of the variety in HOTS definition within the time frame of 1998 until 2013 (Goethals, 2013).

Table 1: Variation of Meanings – Higher-Order Thinking

Source	Year	Definition
King et al.	1998	"(It) includes critical, logical, reflective, metacognitive, and creative thinking. (It is) activated when individuals encounter unfamiliar problems, uncertainties, questions, or dilemmas."
NCTM	2000	"Solving a routine problem."
Anderson and Krathwohl	2001	The processes – analyze, evaluate, and create.
Lopez and Whittington	2001	"(It) occurs when a person takes new information and information stored in memory and interrelates and/or rearranges and extends this

		information to achieve a purpose or find possible answers in perplexing situations."
Weiss, E.	2003	Collaborative, authentic, ill-structured, and challenging problems.
Miri et al.	2007	"… the strategy – the setting of meta-objectives; whereas critical, systemic, and creative thinking are the tactics – the activities needed to achieve the proclaimed objectives."
Rajendran, N.	2008	The expanded use of the mind to meet new challenges.
Thompson, T.	2008	"Non-algorithmic thinking."
Thomas, A. and Thorne, G.	2010	"… (it) takes thinking to higher levels than just restating the facts. (It) requires that we do something with the facts. We must understand them, connect them to each other, categorize them, manipulate them, put them together in new or novel ways, and apply them as we seek new solutions to new problems."
Kruger, K.	2013	It involves "concept formation, critical thinking, creativity / brainstorming, problem solving, mental representation, rule use, reasoning, and logical thinking."

Based on the definition argued by previous researchers, most of them conclude that HOTS is a higher-order thinking which involves critical and creative thinking, logical and reflective thinking as well as the thinking about thinking and metacognitive. However, there are contradiction beyond the context of higher-order thinking such as involving the solving a routine problem (NCTM, 2000) and authentic and challenging problems is designed to promote HOTS require collaboration among students (Weiss, 2003) give HOTS an interesting topic to be discussed, deliberated and studied more.

Despite the variation of HOTS definition, researchers and educators around the globe through their own studies in variety of learning context and educational levels have expressed their consensus on the importance of

teaching and learning HOTS. As cited in Nooraini and Khairul Azmi (2014), according to Black (2005), students could enhance their thinking skills if they were taught about how to think better on something. Kerka (1992) also stressed that teaching students how to think is a very critical effort to be taken seriously in preparing the students to become a better future workers and problem solver.

Noor (2008) concluded that, students need to be prepared for the future to become an independent life-long learner who able to solve problem effectively as well as to become a decisive decision maker. Heong et al. (2011a) also opined that thinking skills is very important in the process of education. A person's thinking habits and ability is highly influenced on his or her capability to learn and therefore HOTS is obviously critical to be integrated in the learning and teaching process in every particular subject.

Chidozie et al. (2014) had suggested in their study that HOTS should be emphasized to be integrated in the teaching and learning process. This is because the main goal of teaching is to develop students' skills in thinking so later they could be able to solve problems critically. This can only be achieved by not just expose them with normal and routine activities but also through a lesson with good integration between subject content and thinking skills which purposefully teach the students how to think well.

From the review of the literature, promisingly most researchers and educators would be on the agreement that students should have the capability on HOTS and the same goes to the fact of the importance of teaching HOTS which mostly agreed as crucially important aspect in the process of teaching and learning. However, teachers might seem to be struggling with devising the best way to prepare their students to do so. The focus question now is how best lessons to be designed to effectively teach HOTS to the students as complementary between subject matter content and the thinking skill aspect.

The Teaching of Higher Order Thinking Skills (HOTS) in Science Education

As explicitly stated in the Integrated Curriculum for Secondary Schools (ICSS), one of the aims of Malaysian secondary school is to develop and enhance students' intellectual capacity. Mariah (2010) in her study had explained that in parallel to this important objective, Science education over the years had moved significantly towards the attainment of developing

students' intellect. In the context of Malaysian Secondary Science education, one of the obvious and important focus of the curriculum as clearly explained in the Malaysian Science Curriculum is to enhance the students' capabilities in thinking skills by stressing on the four important aspects of science process skills, manipulative skills and critical and creative thinking skills. All those specific scientific and thinking skills are blended and framed systematically in the framework of Thinking Skill Thinking Strategy (TSTS) (Malaysia Curriculum Development Centre, 2001).

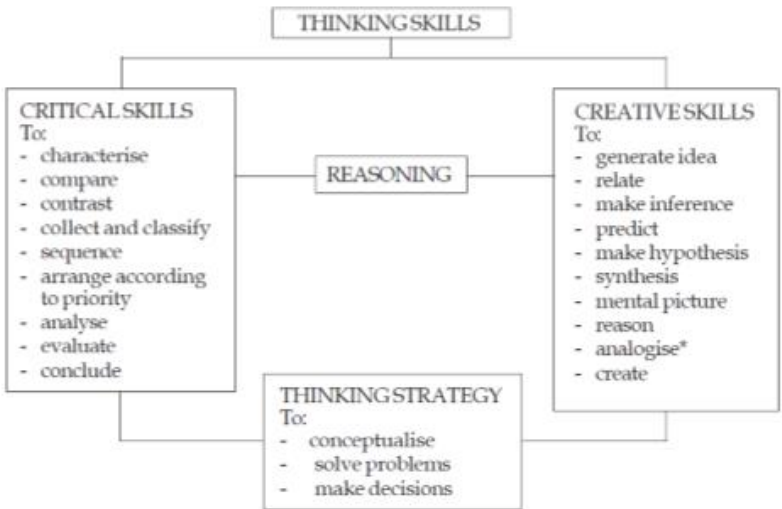

Figure 1: Conceptual Framework of Thinking Skill Thinking Strategy (TSTS)

As shown in Figure 1, TSTS conceptual framework is divided into critical and creative thinking which formed the reasoning skills which in turn to assist a logical, rational and fair consideration to be made later. Each critical and creative skills comprises with several specific and distinct skills. Critical thinking is the skill to evaluate and rationalise the earlier existed and newly found or formed ideas. In contrast, creative thinking is explained as the ability to create and adapt the ideas which is new but genuine.

In accordance with the TSTS conceptual framework, Zohar and Dori (2003) had explained in their research the steps involved in scientific investigation which could promote students' HOTS in a science lesson. This includes clarifying research question, planning and conducting investigation or laboratory experiments, controlling identified variables, generating inference, making arguments, justifying assumptions and searching for a reliable and valid source of reference for information. To understand how the implementation of instructional method that could help in enhancing students' HOTS in science learning and teaching context, the concept of teaching approaches and instructional strategies for instructing HOTS is prior to acknowledge and comprehend.

Approaches in Teaching Thinking Skills

Barakh and Shakhman (2008) had discussed in their research three main different approaches in teaching thinking skills which have been widely discussed as suggested by Ennis (1989). The approaches were named as "process approach", "content approach" and "infusion approach". In the "process approach", thinking skills are taught as a separate subject where the thinking skills are taught explicitly with the objective to give the students a firm knowledge about thinking skills for them to apply on the other specific subject matter.

On the next "content approach", thinking skills are assumed as content within particular subject matter such as Science and Mathematics thus thinking skills should be taught implicitly and specifically within the subject (Ashton, 1988). As for this approach, teachers are required to have comprehensive and deep knowledge regarding their specialisation of subject matter as a strong foundation for them to assist the students on how to apply particular thinking skills within the specific subject content and also able to guide the students to make linkages with other subject matter logically and contextually (Chambers, 1988).

In the third "infusion approach", the teachings of thinking skills are merged with the teaching of specific subject matter content. In this approach, thinking skills are clearly identified and taught throughout the lesson development. Swartz and Parks (1994) whom study the infusion of teaching thinking skills with the teaching of secondary science lesson had stressed that the major focus for the infusion is to maximize the outcome to produce students who would be able to think scientifically and apply the scientific knowledge contextually in their daily life situations.

In supporting the above teaching approaches of thinking skills, as cited in Chidozie et al. (2014), Thomas and Thorne (2009) had suggested that, lessons that are planned and designed to teach HOTS should consist of the following aspects:

a) **Concepts**: Concept is a taught or an idea - a representation of mental that relates facts or ideas formally and informally. Students should be taught to build concepts, as it would help students in activating thinking process, organizing information and constructing knowledge.

b) **Schemes:** Schema is a knowledge arrangement or pattern that already existed in an individual's mental which would assist them to construct and understand new knowledge or information. Infusing this concept into the lessons that promote HOTS would help students to formulate particular new concepts or idea based on the information they have gathered previously.

c) **Metaphors, Similes and Analogies:** Metaphors, Similes and Analogies are methods to further relate and explain the abstract concepts by comparing the similar features between the abstract concepts with a particular concrete object or idea.

d) **Visualization:** Visualization is a mental imagination in a person's mind which could be very useful in enhancing students' HOTS. Therefore, students should be taught how to make a good mental visualization while learning subject matter content because it has equally importance as the written wordings and visible pictures or diagrams.

e) **Inference:** Making inference is to generate conclusion by doing reasoning or deduction on the found evidence or existing arguments and facts.

Strategies for Teaching Higher Order Thinking Skills

As explained by King et al. (1998), teachers need to give clear instructions to their students in giving them a specific task or assignments. This is very crucial in order to avoid confusion and misunderstanding among the students, thus to motivate and encourage the students towards thinking based task or assignments. The researchers had further explained by urging the teachers to systematically and carefully plan the lesson by ensuring several important elements such as well organised learning activities, avoiding ambiguous explanations, showing a good action model in thinking, giving a clear example on thinking application, giving a constructive feedback towards students thinking efforts, ensuring the alignments between learning outcomes and activities as well as planning the lesson that could be well adapted by the needs and diversity of the students.

As cited from Chidozie et al. (2014), Thomas and Thorne (2009) had outlined the nine strategies that could be used for the teaching higher order

thinking which also should be seen as some useful ways to reach the goals of enhancing students' thinking and intellectual capabilities:

a) **Took out the HOTS mystery**
Teachers should teach student purposefully about HOTS; what is HOTS about, why HOTS is very important, how HOTS is best to be learned. This could help to make the students clear about the needs and strategies to develop HOTS among themselves while learning specific subject matter content. This would also guide the students to be aware about the challenges, their strength and weaknesses in developing HOTS among themselves thus could prepare them better to overcome the existing barriers.

b) **Teach concept of concepts**
The teaching of main particular concepts of a lesson needs to be done critically by the teachers. Teachers also need to ensure that the students fully understand the correct features of each concept by not misunderstanding each particular concept to the others. By doing this, students would have the chance to develop their HOTS by practising the analytical skills.

c) **Name and categorize concepts**
In introducing new and key concepts of a lesson, teachers need to make the students aware about it. A clear guidance has to be given to the students on how to categorize the new and previously learned concepts by determining the features of each concepts either process, verbal or nonverbal and abstract or concrete concepts. By practising this, students would enhance their evaluating skills which a higher level thinking as compared to just understand and remembering the concepts.

d) **Move from concrete to abstract and back**
It would be very helpful for the students to be taught in such manner; abstract-concrete and concrete-abstract. In teaching and explaining abstract concepts, a concrete teaching aid would be very effective in making the lesson meaningful and understandable. Students should be continuously guided and encouraged to be able applying the learnt abstract concepts in their daily life situations. By doing this, students would be more motivated in solving problem wisely by applying the learnt concepts in their real life problems.

e) **Teach inference and connect concepts**

To teach students formulating inference is an essential part of the process of developing students' HOTS. This step would be very helpful in training students to make connections between concepts and examining few existing information, facts and evidence before they could produce a meaningful conclusion. In making connections between concepts, students would be able to construct a wider knowledge which later will aid them to have a deeper understanding and avoiding ambiguity about particular concepts or ideas.

f) **Teach question-answer relationships**

Teaching students about the relationship between question-answer is actually explaining to them the type and level of questions being asked and therefore determined the kind of answer which congruent to the type of question. Raphel (1985) as cited in Thomas and Thorne (2009) had explained the two type of question-answer relationship which are: (i) "book question" in which students might get the answer from the text book and (ii) "head question" in which the answer for a particular question is outsourced from the students' real life experience. By realising and knowing the question-answer relationship, students would be more aware about the strategy in searching for information and identifying prior knowledge to carefully answering a question.

g) **Include brainstorming activities in the lessons**

Freewheeling discussion or brainstorming is an effective platform for students to generate a creative or genuine ideas. By allowing the students to discuss and brainstorm on alternative of solutions about an identified problem, they would expose to a great chance to think in a higher level by keep reflecting, generating and challenging ideas upon the other members within the group. This activity will later lead them to reach a common consensus where the meeting point would produce the best solutions for the problem. In brainstorming, the students are actually engaged in higher level thinking skills especially the top three level of HOTS; analysis, evaluation and create (Anderson et al., 2001).

h) **Use teaching techniques that provokes HOTS**

Provoking students' HOTS could be done through several identified teaching strategies. Therefore, teachers need to prepare a proper teaching method or techniques pool for them to choose from the most

suitable method or technique for a particular lesson. The teaching strategies that suited to the chosen method or technique could be in the form of cooperative leaning, mastery leaning and so on.

i) **Emphasise feedback generation for students**
Teacher's evaluation on students' performance in thinking activities should be done in a way of giving the students a continuous feedback. Assessing their ability in responding towards an abstract concept or complex problem would be very useful in explaining the students' strength and weaknesses in HOTS. Then, the students also need to be taught about thinking about their thinking; metacognitive skills which could help them to be more reflective and constructive on their own thinking performance.

The outlined strategies in teaching HOTS as mentioned above might be argued as non-applicable within the specific context of Science education. However, some strategies seem to be well suited and could properly useful in both process of reproducing and constructing Science knowledge as well as the thinking skills.

CONCLUSION

The paper discussed and reviewed some of the existing and established practices, thoughts, concepts, approaches and strategies regarding the teaching of HOTS throughout various fields and levels of education by trying to focusing into the context of Science education. Application of inquiry in teaching and learning science and creating school creative climate is seen promoting HOTS among teachers and students. Jiun and Kamarudin (2014) state that most of the teachers felt that using inquiry-based pedagogies would help them promote their students in some aspects such as increase students' confident level when the students are allowed to explore on their own, classroom management, promotes social interaction and learning from each other and understanding the value of social interaction for learning is a hallmark of the constructivist approach for learning science. Furthermore, Vejian, Kamarudin, and Kadir (2016) found that in creating school creative climate is pertinently significant in supporting a creative teaching and learning process especially in science. Creativity is seen as an influential and important factor in school to further develop the creativity especially in the classroom teaching and learning process. Creative school climate would

cultivate a creative work and behaviour among the school organization members including teachers and students. In rising up the creativity level among among teachers and students by application of HOTS, social dimensions of school climate is prior to be given an extensive attention and considerations. School is a very important basement for the creativity to be nurtured and further develop with good stimulation and support from the conducive and good organizational climate. The conceptual papers aimed as its expected potential contributions and implications is to enrich the literature especially in the teaching and learning practice with special focus on the instructional approaches and strategies that aimed in developing and enhancing students' HOTS particularly in a Science lesson Researchers and educators in Science education should continuously putting their efforts to find out the best way of implementing the teaching of thinking skills in a Science lesson that would promisingly advance the students' capabilities in HOTS. The suggested and discussed strategies in the teaching of HOTS by Thomas and Thorne (2009) should be seen as a starting point in systematically planning and designing Science lesson that could reflect these higher order thinking behaviours among the students.

REFERENCES

Anderson, L. W., Krathwohl, D. R., Airasian, P. W., Cruikshank, K. A., Mayer, R. E., Pintrich, P. R., & Wittrock, M. C. (2001). *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives, abridged edition.* White Plains, NY: Longman.

Ashton, P. (1988). *Teaching Higher-order Thinking and Content: An Essential Ingredient in Teacher Preparation.* Gainesville, FL: University of Florida.

Barak, M., & Shakhman, L. (2008). Fostering higher-order thinking in science class: Teachers' reflections. *Teachers and Teaching: Theory and Practice, 14*(3), 191–208.

Black, S. (2005). Teaching students to think critically. *The Education Digest, 70*(6), 42-47.

Bloom, B., Englehart, M., Furst, E., Hill, W., & Krathwohl, D. (1956). *Taxonomy of Educational Objectives: The Classification of Educational Gals. Handbook I: Cognitive domain.* New York: Longmans Green.

Chambers, J. (1988). Teaching thinking throughout the curriculum-Where else? *Educational Leadership*, *45*(7), 4–6.

Chidozie, C. C., Yusri, K., Muhammad Sukri, S., Wilfredo, L.H., (2014). Implementing higher order thinking skills in teaching and learning of design and technology education. *International Seminar Proceedings on Technical and Vocational Education.*

Costa, A.L. (2002). *Components of a Well-developed Thinking Skills Program*. Retrieved October 27, 2014, from http://www.newhorizons.org/strategies/thinking/costa2.htm

Ennis, R. H. (2002). Goals for a critical thinking curriculum and its assessment. In Arthur L. Costa (Ed.), *Developing minds* (3rd ed., pp. 44–46). Alexandria, VA: ASCD.

Ennis, R.H. (1989). Critical thinking and subject specificity: Clarification and needed research. *Educational Researcher*, *18*(3), 4–10.

Goethals, P.L. (2013). *The Pursuit of Higher-Order Thinking in the Mathematics Classroom: A Review*. Retrieved October 25, 2014, from http://www.usma.edu/cfe/literature/goethals_13.pdf

Heong, Y. M., Othman, W. B., Yunos, J. B. M., Kiong, T. T., Hassan, R. B., & Mohamad, M. M. B. (2011a). The level of Marzano higher order thinking skills among technical education students. *International Journal of Social Science and Humanity*, *1*(2).

Heong, Y. M., Yunos, J. B. M., Hassan, R. B., Othman, W. B., & Kiong, T. T. (2011b). The perception of the level of higher order thinking skills among technical education students. *International Proceedings of Economics Development & Research*, *5*(2).

Jiun, L. T., & Kamarudin, N. (2014). Inquiry in learning science. *International Journal of Technical Research and Applications*, *10*(10), 61–65.

Kerka, S. (1992). *Higher Order Thinking Skills in Vocational Education*: ERIC Clearinghouse.

King, F.J., Goodson, L., & Rohani, F. (1998) *Higher-Order Thinking Skills: Definitions, Strategies, and Assessment*. Centre for Advancement of Learning and Assessment. Florida State University. Retrieved October 25, 2014, from http://www.cala.fsu.edu/files/higher_order_thinking_skills.pdf.

Mainali, B. P. (2012). Higher order thinking in education. *Academic Voices: A Multidisciplinary Journal*, *2*(1), 5–10.

Malaysia Curriculum Development Centre (2001). *Thinking Skill in Teaching and Learning*. Perniagaan Rita Sdn. Bhd.

Maria S. (2010). Developing thinking skills in Malaysian science students via an analogical task. *Journal of Science and Mathematics Education in Southeast Asia*, *33*(1), 110-128.

Marzano, R.J., Brandt, R.S., Hughes, C.S., Jones, B.F., Presseisen, B.Z., Rankin, S.C., et al. (1988). *Dimensions of thinking: A framework for curriculum and instruction*. Alexandria, VA: Association for Supervision and Curriculum Development.

National Council of Teachers of Mathematics (2000). *Principles and Standards for School Mathematics*. NCTM, Reston, Virginia

Noor, A. M. (2008). *Teaching Thinking Skills–Redesigning Classroom Practices*. Brunei: Universiti Brunei Darussalam.

Nooraini, O., & Khairul Azmi, M. (2014). Thinking skill education and transformational progress in Malaysia. *International Education Studies*, *7*(4).

Rajendran, N. (2008). *Teaching & Acquiring Higher-Order Thinking Skills: Theory & Practice*: Penerbit Universiti Pendidikan Sultan Idris.

Resnick, L.B. (1987). *Education and Learning to Think*. Washington, DC: National Academy Press.

Rosnani, H., & Suhailah, H. (2003). *The Teaching of Thinking in Malaysia*. Kuala Lumpur: IIUM Publication.

Olson, S., & Loucks-Horsley, S. (2000). *Inquiry and the National Science Education Standards: A Guide for Teaching and Learning*, Washington DC: National Academic Press, 1-224.

Swartz, R.J., & Parks, S. (1994). *Infusing the Teaching of Critical and Creative Thinking into Content Instruction*. Pacific Grove, CA: Critical Thinking Books & Software.

Thomas, A., & Thorne, G. (2009). *How to Increase Higher Order Thinking*. Retrieved October 25, 2014, from http://www.readingrockets.org/article/how-increase-higher-order-thinking

Vejian, G., Kamarudin, N., & Kadir, S. A. (2016). School creative climate: Factors influence fostering creativity school. *International Journal of Education and Training*, *2*(1), 1–5.

Weiss, E. (2003) Problem-Based Learning in the Information Age: Designing Problems to Promote Higher-order Thinking. Wiley Periodicals, Vol.95, pp. 25-31.

Zohar, A., & Dori, Y. (2003). Higher-order thinking skills and low-achieving students: Are they mutually exclusive? *Journal of the Learning Sciences*, *12*(2), 145–181.

Zoller, U. (2000) Teaching tomorrow's college science courses – Are we getting it right? *Journal of College Science Teaching*, *29*, 409–414.

Zoller, U., & Nahum, T. L. (2012). From Teaching to KNOW to Learning to THINK in Science Education. In B.J. Fraser et al. (Eds.), *Second*

International Handbook of Science Education (pp. 209-229). Dordrecht, The Netherlands: Kluwer.

Zoller, U., & Tsaparlis, G. (1997). Higher-order cognitive skills and lower-order cognitive skills: The case of chemistry. *Research in Science Education*, *27*, 117–130.