SEMINAR NASIONAL PENDIDIKAN SAINS V
"Pengembangan Model dan Perangkat Pembelajaran untuk Meningkatkan Kemampuan Berpikir Tingkat Tinggi"
Magister Pendidikan Sains dan Doktor Pendidikan IPA FKIP UNS
Surakarta, 19 November 2015

MAKALAH UTAMA	**Pengembangan Model dan Perangkat Pembelajaran untuk Meningkatkan Kemampuan Berpikir Tingkat Tinggi**	**ISSN: 2407-4659**

CRITICAL THINKING PROCESS IN SCIENCE LEARNING

Lilia Halim[1], Lilia Ellany Mokhtar[2]
[1,2]Faculty of Education, Universiti Kebangsaan Malaysia
43650, Bangi, Malaysia

Email Korespondensi : lilia@ukm.edu.my

Abstract

Critical thinking is seen as an important competency for academic and career success. In the context of science education, critical thinking is important in order to be an effective citizen in the globalized world powered by rapid scientific and technological development. This paper begins by reviewing the literature on what is science (knowledge and practices), and why critical thinking is important in science learning. The paper then draws on a few studies to demonstrate that critical thinking has two main components knowledge and skills. Also on how to develop components of critical thinking skills effectively. This paper also argues that critical thiking process can only be critical when it is developed with scientific attitude.

Introduction

Scientific knowledge is developed and constructed by scientists through enquiry including employing critical thinking skills with the aim to verify the information as true, valid and reliable. This scientific practices are transferred to school through science education thus the importance of critical thinking processes in science learning. As future citizens, students also need to have critical thinking process so that students can critically examine issues and questions regarding socio scientific issues that have impact on their daily lives.

What is critical thinking in science?

According to Liu (2014), critical thinking is one of higher order thinking skills, believed to play a central role in problem solving. Gunn et al. (2014) further outlines the skills or processes involved in critical thinking namely :conceptualizing, applying, analysing synthesizing, and/or evaluating information

gathered from, or generated by, observation, experience, reflection, reasoning, or communication. In the context of science education, critical thinking skills or processes mirror the science process skills- Such aspects as formulating questions, seeking answers, analysis, interpretation, problem-solving, decision-making, and communication. In other words, critical thinking in science learning is inculcated during laboratory work. At the same time, enquiry activites that require critical thinking can involve non- hands on activites such as solving a scientific issue. In that context, in thinking critically over the a socio scientific issue in a particular context, one would also require deep understanding of the scientific knowledge related to the contexts. Such deep understanding is necessary especially when one has to evaluate critically of the competing theories in solving the socio scientific issues.

How to foster critical thinking in science learning

Since critical thinking is contextual, applying this conception in science education involves focusing on the tasks, problems and issues in the science curriculum which require critical thinking. Examples of challenging students critical thinking are: designing an experiment to test a hypothesis in chemistry, or weighing the evidence and evaluating the argumentation regarding the merits of a technological innovation.

One detail example: Designing an Experiment to Test a Hypothesis

This challenge is geared to intermediate students and involves having them design an experiment to test a causal hypothesis which they have generated after making an observation (for example, that when a glass is placed over a burning candle, the candle goes out). Students would require background knowledge of the physics involved in the phenomenon. Key concepts include hypothesis, initial conditions, and prediction.

Students need to observe the phenomenon in question and having the class generate hypotheses about what caused it; choosing a hypothesis and having groups of students design an experiment to test it; having students critique each other's experiments according to the criteria; having students perform the experiments and discuss what can be concluded about the hypothesis on the basis of the experimental results.

Is critical thinking a knowledge, a process or a habit?

The conceptualization of critical thinking is often as series of procedural moves eg. develop hypothesis, collect data, analyse data and make conclusions. Bailin (2002) argues that such conceptualization could be done in uncritical way. In other words, the science process skills if practiced as procedures as cook book then it does not develop students' critical thinking. At the same time, critical thinking is not employed by students if the critical thinking skills or science process skills are conducted in a cook book manner.

Study by Misbah (2015) on developing science process skills among pre service teachers found that teaching and learning through open scientific enquiry activities were able to develop their science process skills better compared to those who followed guided scientific enquiry activities. This finding indicates that critical thinking skills are developed both through open and guided scientific

enquiry activities but the performance is better for pre service teachers who followed the open ended scientific enquiry activities. The study also found that boys tend to demonstrate their acquisition of critical thinking or scientific process skills better when engage in open ended enquiry. This suggests that open ended enquiry activites are able to develop the need or attitude to be critical in solving a problem or decision making.

Bailin (2002) also reminded us that if critical thinking is conceptualize as a mental process, the problem of such conceptualization is that it is unobservable. As argued by Bailin it can be ony inferred when someone has accomplished a task which requires thinking. In a PhD study by Shalie et al. (in press), he argued that in service teachers were competent in executing the practical component of Science Process Skills (SPS) but lacked the conceptual knowledge underlying the skills. Teachers were not able to describe science process skills adequately. It was found that teachers who have poor conceptual knowledge of SPS are less equipped to use inquiry teaching and related learning strategies in their classrooms. Science teachers from teacher education institutions are not equipped with sufficient conceptual knowledge and consequently are not able to help their students to understand SPS meaningfully.

As suggested by Bailin, when one follows the critical thinking process or science process skills in an uncritical manner than the critical thinking process is not activated or skills not developed thus science learning would just be rote learning. Learning to be reflectively does not occur in that context. What is required according to Bailin is that in order to carry out the set of critical thinking process or skills must be accompanied with an attitude or commonly known as scientific attitude. Scientific attitude or also known as habits of thinking of the scientists – which include suspending judgment, making decisions based on evidence and openness.

Zanaton, Kamisah & Lilia (2006) found that teachers had a lower level of scientific attitude compared to students. If Attitudes, is argued by Gunn et al. (2014) as the vehicle for implementing the concept of scientific critical thinking thus it is imperative that teachers are encouraged and trained to develop scientific attitudes. As suggested by Gunn et al. (2014) and our findings more inquiry based science instruction is needed in the classroom and also in the training of science teachers. The learning science contexts also needs to be diverse not only on doing laboratory work but also involving students and teachers to be involved in socio scientific argumentation tasks. Such a variety of contexts would enhance critical thinking.

Conclusion

Critical thinking is all- cognitive, process and a habit. Learning science effectively depends on the development and employment of critical thinking process. Teachers play an important role in ensuring critical thinking process in science learning. As science educators, it is our responsibility to assist students to think critically about what science is, what is represents, and whether its impact is for the greater good. Teachers must provide the opportunity to develop the attitudes that support active inquiry. Integral is problem solving and decision-making amid

the curriculum content that enhances student's intellectual development and more importantly, creates a readiness for responsible application of what is learned outside the classroom (Gunn et al. 2014)Thus, teachers need to receive relevant pedagogical training program regarding teaching critical thinking skills. Not only to learn the science practices as practised by the scientists but as an effective citizen in their daily lives.

References

Bailin, S. 2002. Critical Thinking and Science Education. *Science & Education,* 11**,** 361–375

Shalie, E., Halim, L., Treagust, D., Won, M. & Chandragesan, A.L. (in press) Primary School Teachers' Understanding of Science Process Skills in Relation to their Teaching Qualifications and Teaching Experience, Research in Science Education,

Gunn, T.M., Grigg, L. M., & Guy A. Pomahac. 2014. *Critical Thinking In Science Education: Can Bioethical Issues And Questioning Strategies Increase Scientific Understandings?* Research Report: University of Lethbridge

Liu, O. L., Frankel, L., & Roohr, K. C. 2014. Assessing Critical Thinking in Higher Education: Current. ETS Research Report Series. 1-23. Educational Testing Service, New Jersey: Princeton