

Socio-scientific Decision Making in the Science Classroom

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Abstract

The learning ability of students in science is improved by socio-scientific decision-making, an important activity that improves a student's scientific literacy, conceptual understanding, scientific inquiry, attitudes, and social values. The socio-scientific issues must be discussed during science classroom activities in the current state of 21st century skills. This paper expands upon how to enhance socio-scientific decision making in the classroom, presenting a detailed thematic review of socio-scientific decision which is relevant to research studies' needs, methods, general knowledge claims, and implications. The methods of studies consist of interviewing, class observation, open-ended questions, free writing, audio-tape recorded discussion, and role play. The result is that it can be recommended, taking into account their findings in teaching processes.

1. Introduction

The study of science is an essential factor to any student's life. Furthermore, the advancement of science serves as a factor in generating rapid changes. Learners in modern days, therefore, have to be equipped with rational thought and the ability to make a decision based on data obtained by information technology. They should also be concerned with the world and with citizenry based upon the 21st century skills. The reformation of science these days is, therefore, in support of scientific literacy [17]. This includes the understanding of the nature of science, appropriate application of scientific concepts, and implementation of scientific process in solving a problem and in decision making.

The goal of science educational reform is based on the nature of the science and also thinking in science classroom. School still remains virtually irrelevant in daily life failing to stimulate learners to their interest and to connect them with their lives. In emphasis of knowledge, students need to have many more skills before entering the labor market or industrial society. Students were not equipped with effective thinking skills in solving a problem and

also in decision making regarding socio-scientific issues in an appropriate manner. Especially democratic education, people should have been granted freedom of expression.

Socio-scientific issues (SSI) are known to be a product of knowledge and technology under public discussion and criticism, whether they are suitable or not in society. Examples include conflicts in nature and public market, social and political implications or even problems concerning health, general living conditions, limited energy supply and economic growth in contrast to environmental conservation among others [16]. It is taken into consideration in the context of socially responsible science teaching encouraging the student's decision based on moral reasoning and a widening scope of scientific literacy [22].

Issues concerning a connection between science and society are new to schools and science courses. A number of teachers and educational administrators still haven't realized the importance in bringing such issues into applying in related courses. Teaching was specially based on the content alone. In effect, students became deprived of thinking skills and the usage of knowledge in science beyond their school. They also lacked of skill in decision making and in working in groups. These skills are generally known as essential in a successful work environment [15]. Teachers failed to give students a chance to discuss and debate before making a decision. They did not pay attention to promote the morality essential to life among students. They have not been developed in terms of potential in socio-scientific decision making [16]. Furthermore, the knowledge of science had never been applied in decision making process.

Decision making based on socio-scientific issues (SSI) refers to one of the four goals for school science under National Science Education Standards [12]. Socio-scientific decision making serves as a solution based on the learner's choice and study of data analysis of which concerns the stakeholders. The factors would be considered in search of possible choices before finding the right choice and making a decision based on scientific knowledge, conceptual understanding, the nature of scientific inquiry, value clarification, and argumentation [11]. Socio-scientific decision making needs a

standardization and acceptance based on justice and human rights. Those with potential in considering socio-scientific decisions are in need of considering possible impacts on morality as well [13]. Moral and ethical dimensions are to be a stand point in discussing socio-scientific issues [22].

The aim of this study is to investigate socio-scientific decision making, reported in the literature about socio-scientific decision making concepts. In this context, the following questions were asked:

1. What are the decision making frameworks?
2. What are the methods of analysis?
3. What are the data collection techniques?
4. What kinds of implications have been suggested in the studies?

2. Literature Review

As a result of investigating databases such as ERIC, Springer, EBSCOHOST and ThaiLIS, related to socio-scientific decision making. As a result of the first classification, these studies were found to concentrate on the subjects of teaching socio-scientific issues (SSI), students' reasoning processes in making decisions about SSI, and decision making framework for SSI. Therefore, this paper emphasizes the enhancement of decision making through SSI and related concepts' in the last three decades.

After reviewing related researches, the author found that there was an emphasis on the development of socio-scientific decision making using issue-based approaches, which can be shown below.

Lee [9] cited in his study that there is a great diversity of socio-scientific issues, more work still needs to be done at the classroom level to identify evidence-based pedagogic practices which can enhance a students' decision-making ability. An issue-based approach could be used to guide students towards informed decision-making, by promoting their conceptual understanding, understanding of scientific inquiry, attitudes, values, and their ability to engage in rational arguments. Lee and Grace [10] stated that a decision making framework adapted from the literature was designed to help students tackle the issue from multiple perspectives with due consideration given to relevant scientific knowledge, rational argumentation, and the values underlying the possible options.

Grace [5] suggests that biodiversity conservation is an important socio-scientific issue that is often regarded as a precondition to sustainable development. The foundation for citizens' understanding of conservation issues can be laid down in formal school education. It can focus on decision-making discussions about biological conservation issues among 15–16-year-old students. Findings indicate the positive value of students taking part in these short decision-making

discussions guided by a structured framework and as part of their normal science classroom activities. Students increase their quality of personal reasoning, and modify their solutions to the issues. These issues provide students with a context that encourages active reflection and examination of relevant connections among science, their own lives and the quality of life in their community [23]. Most students relied upon multiple perspectives when making their decisions. It was found that when students used multiple viewpoints, the perspectives were unequally valued, generally relying more on ethical perspectives [6].

Walpuski et al [20] found that decision-making and argumentation are competences concerning decision-making and are highly dependent on how frequently students are given the chance to debate in science classes. The enhancing decision making of students could be implemented in conventional classroom by assigning the decision making framework to the students. This could develop informed decision making based on brain-storming and provide multiple perspectives with peer group by promoting their conceptual understanding, realization of scientific inquiry, attitudes and values, and their ability to engage in rational argumentation.

At present, the management of knowledge derived from issues concerning science and society are considered important in the study of science, making learners realize that their learning is meaningful in relation to their lives. Socio-scientific issues are applied in generating an interest in argument-based learning among learners and a discussion based on scientific knowledge and data [14]; it serves as the best means in stimulating learners to develop skills in using a reason and making a decision in concern with socio-scientific decision making. A current reformation of the study of science tends to support the scientific advancement toward establishing morality and ethics in a scientific dimension, instead of teaching solely a science-based content, diversifying teaching based on learning techniques and scientific concepts, philosophy, history, society, values and ethics. The use of socio-scientific issues responds to these scientific needs [21]. The use of scientific knowledge before applying it to other situations in concern with social and moral context stimulates learners to find truth, opening their mind to the opinions of others and being able to negotiate carefully and systematically based on their rationale. Moreover, it promotes the quality of citizenry and social consciousness [23].

3. Methodology

Within the framework of the research questions posed to examine the decision making frameworks and data collection methods, the following studies were based on an analysis using a matrix, which

consists of two basic elements, i.e. decision making frameworks, data collection methods. The research questions posed to examine the decision making frameworks and data collection methods, the studies were based on an analysis using a matrix, which consists of two basic elements, i.e. decision making frameworks, data collection methods. It can be shown in Table 1 and 2.

Table 1: The examining the decision making frameworks

Research Studies	Decision making frameworks										
	DP	IS	CI	GO	CO	FC	MR	MD	RA	RD	
Kortland (1996)	/			/		/		/	/		
Ratcliffe (1997)			/	/	/	/		/	/		
Campbell et al., (1997)	/	/	/								
Edelson et al., (2006)		/			/	/					
Kaewmuang moon (2008)	/	/	/		/			/			
Lee and Grace (2010)		/		/				/			
Yu, (2010)			/				/		/		
Walpuski et al.,(2012)		/	/						/		
Lee and Grace (2012)		/	/	/	/	/	/	/	/	/	

DP = Defining the problem, IS= Identifying stakeholders, CI =Collecting information, GO =Generating options, CO =Considering pros and cons of options, FC=Formulating criteria for evaluating options, MR=Developing moral reasoning, MD=Making decisions, RA=Reflection among students, RD= Reflection in a different location

Decision making framework serves as a guide for students so that they were able to consider the issue from multiple perspectives.

Table 2. Data collection techniques

Research Studies	Data collection techniques							
	I	C	O	M	F	A	R	U
Kortland (1996)								/
Ratcliffe (1997)					/	/		
Campbell et al., (1997)							/	
Edelson et al., (2006)								/
Kaewmuang moon (2008)			/		/			

Lee and Grace (2010)	/	/	/		/	/		
Yu, (2010)			/					
Walpuski et al.,(2012)			/		/			
Lee and Grace(2012)		/	/	/	/			

I=Interviews, C =Class observation, O =Opened question, M =Multiple choice,F =Free writing, A=Audio-tape discussion, R =Role play, U =unclear

The triangulation of data in researches increases the reliability and validity[3]. Therefore mixed methods are usually preferred [7]. When Table 2 is examined, it can be seen that researchers collected data using interviews, class observation, open ended questions, multiple choice, free writing and role play. Among the studies, 9 were found to include multiple methods of data collection.

The data collection techniques and methods of analysis used in the studies were conducted to determine how socio-scientific issue decision making is enhanced.

4. Findings

The study found that Kortland [8] conducted a study to explore a decision making of students aged 13-14 in the Netherlands, after teaching the students arguments about a decision making situation had improved as far as clarity of the criteria used for evaluating alternatives is concerned. Ratcliffe [15] conducted a study to explore a decision making on environment issues. The result found that the appropriate framework to follow during discussion among small groups of 15 year olds being able to begin to address. However, the written work was examined alongside the audio-taped discussion. Grace [4] and Lee [8] found that the positive value of students taking part in short decision-making discussions was guided by a structured framework as part of their normal science classroom activities. Campbell et al [2] published a student-centered curriculum with provide a model for decision making focused on defining the problem and emphasized identification of values and role play in decision making. Edelson et al [4] created the Stakeholder consequence Decision making (SCDM) for high school students. He found that decision making process was accessible and engaging to a broad range of students. Lee [9] found that data on the outcomes and student feedback were collected from the student worksheets, class observations and student interviews. A group of five students from each class was interviewed after the lesson. Lee and Grace [10] and found that initial and final decisions of the students reveals notable changes in their

reasoning after carrying out the activity. They made less appeal to anthropocentric values and showed a greater inclination toward a perspective of biocentrism. Kaewmuangmoon [19] said that the students could make socio-scientific decision making after the curriculum implementations were significantly different at 0.05 above the cut-off score of the socio-scientific decision ability test. Lee and Grace [11] found that in different contexts, students had shared different perspectives on reasoning, evidence of data collection, decision criteria along with some decision making behavior in solving similar socio-scientific issues. Yu [21] explained that socio-scientific issues could support the learning of science in relation to morality and ethics along with enhancing the student's obvious ability in ethical terms and other elements that influence their lives; such as an export of electronic waste to poor developing countries, etc. This points out that morality has an important role in a student's decision making.

The most important results obtained by the researchers were given in concern with decision making in issues regarding sciences at national and international levels. It was found that one should develop an academic curriculum on a relative quantity emphasizing the development of potential in solving a problem and doing decision making. Sungsewo

[18] discovering that such an ability have been in solving a problem and decision making with points in finding solution and decision making higher than the crossover point. Kaewmuangmoon [19] discovered that students had decided to work on socio-scientific decision making in a higher level than the crossover point of the test of ability in decision making concerning socio-scientific issues. During a process of decision making of secondary high school students regarding nuclear physics, based on the management of scientific, technological and social ideas (STS) Anantasook [1] found that decision making done by individual students had a more consistent pattern because of their experience in group work. Students with different intelligence tended to have different processes of decision making based on a mutual decision in their group. It was indicated that the majority of the mentioned research are based on either qualitative or quantitative data. As a result, the obtained data were not sufficient for analysis and conclusion, undermining reliability. Furthermore, the majority of research, in emphasis of developing curriculum, does not specify or in cases of a study of decision making, each step was independently classified. In an international level of research, there were those who had studied the issues and their related ones. Lee and Grace [9] pointed to an importance in the process of seasoning of students in concern with socio-scientific decision making under a wide variety

of biodiversity under the scope of a particular decision making by stimulating students through brain storming to generate different perspectives. In this process, the teacher has a role in supporting and guiding the student through appropriate solutions, discussing pros and cons, framing criteria in selecting a choice and reflecting a result of their decision. Besides, they would have to develop a scientific concept in tackling relevant issues so that the student could realize it and make use of it as a knowledge base for decision making. It was discovered that the participant students were able to use scientific knowledge more effectively than they used to before joining the experiment. Anthropocentric values are based on the benefits of human beings alone and values of biocentrism feature a mutual win-win between humans and other organisms. Students became more confident in a process of decision making. Besides that, Lee and Grace [10] found that in different contexts, students had shared different perspectives on reasoning, evidence of data collection, decision criteria along with some decision making behavior in solving similar socio-scientific issues. It was discovered that in different contexts, the framing of decision making would be different generating perspectives in reasoning and reflecting different metacognitions. Qualitative discussion would be based on the student's chances in group work. Meanwhile, Yu [21] explains that socio-scientific issues could support the learning of science in relation to morality and ethics along with enhancing the student's obvious ability in ethical terms and other elements that influence their lives; such as an export of electronic trash to poor developing countries, etc. This points out that that morality has an important role in the student's decision making. The study of science in the future should, therefore, emphasize on socio-scientific issues.

5. Conclusions

The results are summarized and presented as follows:

1. Decision making frameworks serve as a guide for students so that they were able to consider the issue from multiple perspectives.
2. Decision making on SSI is important in developing scientific conceptions and clarifying the misconceptions.
3. Conservation issues are a prerequisite to making informed decisions about wider issues of sustainable development.
4. Decision making on SSI consists of conceptual understanding, nature of scientific inquiry, value clarification, and argumentation.
5. Debating serves as a teaching approach to enhance understanding of socio-scientific issues and

to encourage critical thinking leading to better decision-making.

6. Issue-based approaches could be used to guide students towards informed decision-making. It promotes the students' conceptual understanding, understanding of scientific inquiry, attitudes and values, and their ability to engage in rational argumentation.

The need and relevance of emphasizing decision making in science teaching have also been argued by several educators through the last few three decade. Based on the mentioned principles and theories, it was found that lower secondary school students became an important target in developing the ability in socio-scientific decision making. Students learning science this way would not just memorize information, but they would use scientific thinking to make everyday decisions. However, there is no current form of teaching to develop socio-scientific decision making, a future research should be developed to support the style for lower secondary school students in correlation with a reform in the study of science in the future.

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7. References

- [1] Anantasook, A. *Students' Decision Making Process in Physics Learning about Nuclear Physics Through Science Technology and Society (STS)*. Master of Education Thesis in Science Education, Khon Kaen : Khon Kaen University, 2011.
- [2] Campbell, V., Lofstrom, J. and Jerome, B. *Decision Based on Science*. Virginia: National Science Teachers Association, 1997.
- [3] Cohen, L., Manion, L. and Morrison, K. *Research Methods in Education*, 6th ed. New York: Routledge, 2007.
- [4] Edelson, C. D., and others. "Learning to Make Systematic Decision," *The Science Teacher*. April/May 2006, pp. 40-45.
- [5] Grace, M. "Developing high quality decision-making discussions about biological conservation in a normal classroom setting," *International Journal of Science Education*, 2009, vol.31, no.4, pp. 551-570.
- [6] Halverson, K. L. and Siegel, M. A. and Freyermuth S. K. "Lenses for Framing Decisions: Undergraduates' decision making about stem cell research," *International Journal of Science Education*. 2009, vol.31, no.9, pp. 1249-1268.
- [7] Harrison, A.G. & Treagust, D.F. "Learning about atoms, molecules, and chemical bonds: A case study of multiple-model use in grade 11 chemistry," *Science Education*, 2000, vol.84, pp. 352-381.
- [8] Kortland, K. "An STS case study about students' decision making on the waste issue," *Science Education*, 1996, vol 80, pp. 673-689.
- [9] Lee, Y. C. "Developing decision-making skills for socio-scientific issues," *Journal of Biological Education*, 2007, vol.41, no.4, pp. 170-177.
- [10] Lee, Y. C., and Grace, M. "Students' reasoning processes in making decision about an authentic, local socio-scientific issue: bat conservation," *Education Research*, 2010, vol.44, no.4, pp. 156-165.
- [11] Lee, Y. C., and Grace, M. Socio scientific Issue: A Cross-Context Comparison. Students' Reasoning and Decision Making About a Sttp://www.wileyonlinelibrary.com,2012 (Access date : 9 August 2012)
- [12] Nation Research Council. *National science education standards*. Washington, DC: National Academy Press, 1996.
- [13] Pedretti, E. "Decision Making Social and STS Education: Exploring Scientific Knowledge and Responsibility in Schools and Science Centres Through an Issues- Based Approach," *School Science and Mathematics*, 1999, vol. 94, no.4, pp.174-181.
- [14] Nuangchalerm, P. "Engaging students to Perceive Nature of Science through socio scientific issues-based Instruction," *European Journal of Social Science*. vol.13, no.1, pp.34-37, 2010.
- [15] Ratcliffe, M. "Student decision-making about socio-scientific issues within the science curriculum," *International Journal of Science Education*, 1997, vol.19, no.2, pp.167-182.
- [16] Sadler, T. D., and Zeidler, D. L. "Patterns of informal reasoning in the context of socio scientific decision making," *Journal of Research in Science Teaching*, 2005, vol.42, no.1, pp.112-138.
- [17] Sadler, T. D., and Zeidler, D. L. "Student conceptualizations of the nature of science in response to a socioscientific issue," *International Journal of Science Education*, 2004, vol.26, no.4 ,pp. 387-409.
- [18] Singsewo, A. *Developing of School Based Curriculum on Stoichiometry with Emphasis on Development of Problem Solving and Decision Making Ability*. Dissertation, Ed.D. (Science Education). Bangkok: Srinakharinwirot University, 2006.
- [19] Kaewmuangmoon, S. *A Development of the Upper Secondary Science Curriculum on Genetics to Enhance Socio-Scientific Decision Making Ability*. Dissertation, Ed.D. (Science Education). Bangkok: Srinakharinwirot University, 2008.

[20] Walpuski.M, Tepner.O, Sumfleth.E, Dollny.S, Hostenbachs.J, Pollende.T. "Multiple perspectives on students' scientific communication and reasoning in chemistry education," *Acta Didactica Norge Conference Vision Teaching*, 2012. vol. 6, no.1, University Duisburg-Essen.

[21] Yu, Y. *Adults' Decision-making about the Electronic Waste Issue: The Role of the Nature of Science Conceptualizations and Moral Concerns in Socio-scientific Decision-making*. Dissertation, Ph.D. (Art and Science). Columbia: Graduate School, Columbia University, 2010.

[22] Zeidler, D. L., and Keefer, M. "The role of moral reasoning and the status of socio-scientific issues in science education: Philosophical, psychological and pedagogical considerations. In D. L. Zeidler (Ed.)," *The Role of Moral Reasoning on Socio scientific Issues and Discourse in Science Education*, 2003, pp.7-38. Netherlands : Kluwer Academic Publisher.

[23] Zeidler, D. and B. Nichols. "Socio scientific Issues Theory and Practice," *Journal of Elementary Science Education*, 2009, vol.21, no.2, pp. 49-58.

[24] Zeidler, D. L., Sadler, T. D., Applebaum, S. and Callahan, B. E. "Advancing reflective judgment through socio scientific issues," *Journal of Research in Science Teaching*, 2009, vol.46, no.1, pp.74-101.