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Integrating Socio-Scientific Issues to Enhance the Bioethical Decision-Making Skills of High School Students

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Abstract

Scientific literacy has been focused on the construction of students' knowledge to use appropriate and meaningful concepts, critically think, and make balanced, well-informed decisions relevant to their lives. This study presents the effects of integrating socio-scientific issues to enhance the bioethical decision-making skills of biology students. Using a quasi-experimental research design, results of the independent and related samples *t*-test on the pre- and posttest mean scores of 72 students significantly revealed that integrating socio-scientific issues in biology lessons are useful to enhance their bioethical decision-making skills. Moreover, as socio-scientific issues were integrated in their lessons, students' classroom interactions and argumentations improved significantly and enabled them to give a positive, more elaborate, and in-depth responses with a wider range of explanations.

Keywords: bioethics, decision-making skills, science education, socio-scientific issues

1. Introduction

1.1 Background of the Study

In recent years, science education started to highlight the use of socio-scientific issues in the teaching and learning process. In fact, the use of socio-scientific issues in education served as an approach to make science learning more relevant to students' lives (Cajas, 1999; Pedretti, 1999), a venue in assessing students' learning outcomes and appreciation of the nature of science (Bell & Lederman, 2003; Sadler, Chambers, & Zeidler, 2002; Zeidler, Sadler, Simmons, & Howes, 2004), and as an important component in enhancing scientific literacy (Driver, Newton, & Osborne, 2000; Pedretti & Hodson, 1995). In the study of Ratcliffe and Grace (2003), using socio-scientific issues in secondary science classrooms enabled students to identify the strengths and weaknesses of their own reasoning aside from enhancing their awareness on the relationships of science and society (Sadler, 2004; Zeidler, 2005). This teaching approach was useful in developing scientifically-literate individuals who use their scientific knowledge to build a competent community who decides and performs actions and participates in any form of inquiry objectively (Tal & Kedmi, 2006). Also, the inclusion of controversial socio-scientific issues in science lessons had the potential to train students who are objective in their decision making processes (Kolstoe, 2001; Millar & Hunt, 2002; Millar & Osborne, 1998; Monk & Dillon, 2000).

One of the basic goals of education is to develop students' critical thinking and decision making skills. These skills can be enhanced through the integration of socio-scientific issues in the life science classes because the application of scientific knowledge is one of the primary concerns of the subject matter. In exposing students to these issues, they will share the responsibility of valuing inquiry on moral issues linked with technology. This is to equip them with the ability to assess increasing amounts of information in their everyday lives (Butchart, Biglow, Oppy, Korp, & Gold, 2009). This can also lead them to better understand and simplify on their own the growing complexity of their ideas. In the previous years, science education has inspired many students to further pursue a career in the applied sciences or in science-related fields such as engineering and medicine (Jones, 2007). Thus, there is really a growing interest of using socio-scientific aspects of science in order to spark students' interest as well as build their sense of responsibility as they explore the practical utility of science and the potentials of technology in human development. Moreover, socio-scientific education has set the primary goal of promoting the development of students' moral judgment and ethical values especially during classroom guided discourses (Zeidler et al., 2004).

The concern with the social aspect of science served as the bridge towards the emergence of ethics in the biosciences. Ethics aims however, to instill in the minds of students their heightened sensitivity to make better sense of the social aspects of science education. In fact, the elaborate role of bioethics includes increasing ethical knowledge, improving ethical judgment, and making students "better people by making them more virtuous or otherwise more likely to implement normatively right choices" (Reiss, 2006, p. 15). Moreover, exploring ethical perspectives in biological studies would stimulate the interest of students (Levinson, 2003) aside from developing them to be socially responsible (Finegold, 2001). A study conducted in England and Wales found out that teachers believed the improvement of the self-confidence, the enhancement of the critical thinking, and the development sensitivity to the rights of others of 14 to 19 year-old students when socio-scientific issues were included in their classes (Levinson, Douglas, Evans, & Turner, 2001). Further, many teachers are using bioethical issues as a process of imparting a set of skills and attitudes that give students the opportunities to explore current ethical questions in personally meaningful ways (Pumahac, Gunn, & Grigg, 2007). As a result, students developed bioethical maturity with considerations of the multicultural and diverse society as stated in the Universal Declaration of Bioethics and Human Rights (UNESCO, 2005). According to Macer (2004), bioethical maturity is the ability to recognize the different ethical frameworks which are used to consider ethical dilemmas. This covers the skills such as understanding the diversity of ideas, balancing the benefits and risks of science and technology, and using reasoned approaches in making decisions combining scientific data with ethical views (Macer, 2004).

1.2 Decision-Making Skills

Throughout the continuous development of the scientific fields, scientists and the healthcare professionals have been extensively engaged in expressing their decisions. These decisions however, are influenced by their past experiences combined with the emerging ideas of science. Because of this, science educators worldwide continue their advocacies in improving the processes of science teaching and learning. Acar (2008) claimed that argumentation can be an instructional method to improve reasoning and decision-making skills in science classrooms (Acar, 2008). Using socio-scientific issues in science classrooms, students can be trained in developing objective and empirical evidences, using trade-offs, or in weighing their arguments to reach an informed decision (Ratclifee, 1997; Grace, 2009; Seethaler & Linn, 2004; Siegel, 2006; Zohar & Nemet, 2002; Jimenez-Alijandre & Pereiro-Muñoz, 2002). These can be done through cooperative learning approaches where students are provided with opportunities to interact with each other as they provide explanations for their claims, engage in discussions, and formulate their own arguments (Kirchner, Paas, & Kirshner, 2009; Mevarech, 1999).

The process of decision making is one of the most complex mechanisms of human thinking as various factors and courses of action intervene with it (Lizárraga, Baquedano, & Cardelle-Elawarc, 2007). Competent decision making requires several key skills including the ability to process information in an internally consistent manner and the skill to identify the relevance of having varied views that inhibits impulsive responses (Finucane & Gullion, 2010). In order to arrive at a good decision, one must determine the goals to be achieved, generate alternatives that lead to attaining the proposed goals, evaluate whether these alternatives meet one's expectations and, lastly, select the best alternative with an efficient global result (Halpern, 1997). This process can be influenced by several variables such as personal, environmental, and psychological phenomena (Lizárraga, Baquedano, & Cardelle-Elawarc, 2007). Lizárraga et al. (2007) noted in their study that gender and age are two of the psychological factors that influence decision-making skills. Results of their study showed that women tend to be more concerned with uncertainty, doubts and the consequences that may be derived from the decision while men gave more importance to the goals and purposes as well as to the analysis of the information required to carry out the decision.

In trying to understand, assess, and improve decision making, Rowe and Mason (1987) recognized cognitive complexity and values orientation as the basic framework of the decision-making process which branch out into four different styles: directive (focusing on the technical aspect), analytical (focusing on forecasting events using the data), conceptual (focusing on assigning more importance to the analysis of the information required to carry out the decision and to the definition of the goals or purposes of the decision), and behavioral (focusing on people and peers and how decisions are globally acceptable). These frameworks can be combined as students are engaged in the processes of understanding and describing the problem, developing possible solutions on the basis of relevant information, and in evaluating possible solutions (Ratcliffe & Grace, 2003; Eggert & Bögeholz, 2010; Bernholt, Eggert, & Kulgemeyer, 2012).

In the past, the components of the decision-making process have been studied individually but recently, the understanding of individual decision-making skills has progressed and began to address the interrelationships of variables (Bruin, Fischhoff, & Parker, 2007) including demographic characteristics such as socio-economic status (SES), age, and cognitive abilities. Critical to this process is becoming aware of the emotional states of others which can be addressed through face-to-face interactions and the readiness to accumulate and objectively weigh the pieces of information (Aldona, 2004). This supports the claims of Marttunen, Laurinen, Litosseliti, and Lund (2005) that Piagetian research tradition find socio-cognitive conflict an essential element in a person's learning. Moreover, Vygotskian research tradition emphasizes that learning is mainly a result of interactive and social processes (Marttunen et al., 2005).

Several authors suggest that more analytic information processing seems to be related to better decision making. Normative models of decision making typically identify four fundamental skills such as belief assessment involving judging the likelihood of outcomes, value assessment involving evaluating outcomes, integration involving combining beliefs and values in making decisions, and metacognition which means knowing the extent of one's abilities (Finucane & Lees, 2005; Parker & Fischhoff, 2005). In a study conducted by Gresh, Hasselhorn, and Bögeholz (2013), a web-based training program with additional metacognitive prompts to support students' task analysis enhances their decision making process on socio-scientific issues with respect to evaluating solutions.

In normal, argumentative discussions, socio-cognitive conflicts serve as an essential part in students' learning. It usually arises when one identifies a difference between his prior knowledge and his new knowledge. This knowledge discrepancy usually triggers the need to solve the conflict—to find new information in order to explain the different conceptions and to maintain one's mental balance (Marttunen et al., 2005). Argumentation theory emerged from the need to define logic that occurs in everyday contexts consisting of topics based upon analytical arguments in which conclusions were drawn from the premises (Acar, 2008). An essential pedagogical aim of argumentation is met when students are engaged in counter-argumentation and decision making, thereby familiarizing themselves with others' standpoints contrary to their own opinions (Marttunen et al., 2005).

The advocacy to integrate science and morality in the basic science education has encoragaed the development of a curriculum where teaching approaches respond to the development of students understanding of socio-scientific issues and their own values and ethics and their appreciation of the social context in which science operates (Abd-El-Khalick & Lederman, 2000). This is consistent to the call of Driver et al., 2000 that science education should provide students with opportunities to learn about science concepts and view its nature as a social practice. The use of socio-scientific education in an argumentative classroom environment has increasingly been popular to enhance the development of the decision-making skills of students. This is because the use of socio-scientific issues encourages students to confront the moral aspects of emerging scientific knowledge as they engage in decision making activities largely determined by their personal and moral considerations (Sadler & Zeidler, 2005).

In the study of Pascarella (1989), the development of argumentation and decision-making skills is mainly a product of the long-term engagement in academic discussion environment (Pascarella, 1989). Students need experience and practice to develop justification of their claims, to recognize and address counter-arguments, and study about the elements that make up a strong justification (Sadler, 2004; Herrenkohl & Guerra, 1998). As students are exposed to argumentation in socio-scientific education, they are likely evoked to incorporate emotive considerations and consciously use related affective factors in arriving at moral decisions (Sadler & Zeidler, 2004). In an interview conducted by Fleming (1986) among adolescents with a mean age of 17.3 years old regarding nuclear power and genetic engineering, 70% of the students employed moral reasoning in the resolution of the issues posed. Moreover, in the study of Bell and Lerdeman (2003), 85% of the students' responses involved moral, ethical, or value considerations when asked on the issues of fetal tissue implantation, the relationship between diet, exercise, cancer, global warming, and the link between cigarette-smoking and cancer.

1.3 Approaches in Integrating Socio-Scientific Issues in Life Science Classes

Integrating socio-scientific issues in life science classes is a challenging task to most of the teachers because it seems revolutionary to the traditional laboratory-dominated classroom activities. More often than not, it requires enthusiasm for teaching in interactive ways rather than by strict moralistic modes (Downie & Clarkeburn, 2005) to elicit bioethical judgment. In fact, using socio-scientific issues in the teaching and learning process aims to make students be more open-minded (Clarkeburn, 2000). Thus, there is really a need for clear emphasis on professional ethics among students to develop their clear picture of the best professional science practices in their future careers. Making value judgment on either professional or personal issues is thus best to develop among students during their early stages of education. This also trains students to become individuals who among students during their early stages of education. This also trains students to become individuals who possess the right science process skills and who are aware of the ways to reach, use, share, and produce their knowledge in an appropriate manner (Aktamis & Yenice, 2010).

In most of the social sciences and humanities subjects, well-established pedagogic practices for teaching students to discuss issues and construct reasoned arguments are defined. In science education, there is really unclear pedagogy on the appropriate approach to integrate socio-scientific issues in the classroom. On the contrary, science teachers are required to facilitate the development of students' ability to understand valid ways of constructive arguing and enable them to recognize the strengths and limitations of scientific argument (Osborne & Young, 1998). Prerequisite to this is their basic ability of identifying ethical issues in the science context and their skills to recognize and construct scientific arguments on their own. Levinson (2006) presented a three-stranded framework for teachers in teaching socio-scientific issues: 1) categories of reasonable disagreement; 2) the communication virtues or dispositions necessary to engage in reasonable disagreement; and 3) narrative modes of thought and experience which can best illuminate the disagreement.

Argumentation in science classrooms significantly offered an avenue to improve the understanding of the cognitive content of the nature of science that many would argue, is an essential outcome of science education today (Osborne, Simon, Erduran, & Monk, 2001). In fact, argumentation is the cornerstone of developing students' science process skills (Bell, 2004) which can be done through collaborative discourse focusing on students' claims and justifications of socio-scientific issues (Osborne, 2010). This is because according to Chowning, Griswold, Kovarik, and Collins (2012), using socio-scientific issues in the argumentative processes in the classroom not only exposes students on the scientific backgrounds of socio-scientific data but also on the stakeholder perspectives, and ethical principles. In Australian high schools, teachers provided opportunities for students to develop and practice argumentation skills in order to develop their scientific literacy (Dawson & Venville, 2010).

Case analysis is another approach to integrate socio-scientific issues in the life science classes because these are often coupled with moral and legal issues that directly relate to the lives of students. More often than not, these cases would involve scientific discoveries and technological advances that must be discussed in public (Heuer, 2008). The case study method is a useful alternative to lecture method because it gives students the opportunity to take part in the learning process through their active participation in classroom interactions (Hessler, 2006). D. Johnson and R. Johnson (1988) claim that in case study approaches, students gain greater mastery and retention and develop a greater ability to generalize the principles they have learned.

Workshop is another method in integrating socio-scientific issues. It employs role-plays and other interactive techniques which are possible to achieve even in large classroom settings (Downie & Clarkeburn, 2005). In workshop activities, students are free to express positive ideas in the identification of related topics relevant to issues being discussed. Moreover, students are given enough time to collaborate with each other thereby maximizing their peers' contributions in shaping their ideas.

Debates were also used as another method in the integration of socio-scientific issues in science classes. Yazici and Altiparmak (2010) noted in their study that debates on bioethical issues with the aid of science fiction presentation together with the watch-discuss-exhibit methods (cooperative learning, brain storming, poster exhibition and group research) were observed to be the most effective method in increasing the students' academic success and in developing their judgment towards biotechnology and bioethics. Through science fiction presentations, students imagined and made new constructs during ethical discussions so they are able to grasp the issues both theoretically and experimentally with positive attitudes (Yazici & Altiparmak, 2010).

2. Method

2.1 Research Design

This study used the quasi-experimental design. One group was the Socio-scientific Issues Integration (SSI) Group and the other group was the Conventional Group. Both groups took a pretest and a posttest on decision-making skills. The difference between the mean pretests and the posttests scores were compared within and across groups to determine the effects of socio-scientific integration on the bioethical decision-making skills of the students.

2.2 The Sample

The research participants were Grade 8 students from two intact classes in a public high school in Region 4A, Philippines. The two classes were randomly assigned to either the SSI Group or the Conventional Group.

2.3 The Instrument

A Decision-making Skills Questionnaire (DMSS) was administered to test the skills of the students. Items in the questionnaires were adapted, modified, and tested for reliability and validity with experts in the field of educational research. All items were written in English and Filipino (local language) for clarity in the contexts of the ideas presented.

Prior to implementing the intervention, the instrument was pilot tested to 17 peer-teachers in the field of Biology and 39 Grade 9 students. The instrument was subjected to inter-rater agreement analysis (Cohen's kappa) as presented in Table 1 prior to its administration. Kappa values for the DMSS in Table 1 show that the rating of the scores of both the peer-teachers and the students yielded an agreeable value ($p > .70$). This means that there was clarity on the presentation in the criteria of the rubrics used and that the raters had a common, clear, and unified agreement during rating.

Table 1. Reliability coefficients obtained for the Decision-Making Skills Survey (DMSS)

Research Instrument	**Nature of Respondents**	**Total Number of Cases**	**Cronbach's Alpha**	**Number of Items**
DMSS	Peer-teachers	17	.77	9
	Students (Pilot test)	39	.79	9

This questionnaire was patterned after the US Federal Emergency Management Agency (US FEMA). Items were mostly focused on bioethical issues concerning biotechnology, environmental degradation, and cancer research. Four scenarios with 2 to 3 open-ended questions were prepared which aim to measure the decision-making skills of students. Each of the questions had two (2) to five (5) maximum points as indicated. In this instrument, students were required to process the information presented and make decisions considering scientific, technological, ethical, moral, and public policies. Rubrics were patterned from the US FEMA Decision-making Skills and Problem-solving Skills Independent Study and validated by experts in the field of biology.

3. Results and Discussion

Scientific literacy is the capacity to pose, identify and evaluate scientific issues underlying national and local decisions, and express positions that are scientifically and technologically sound (Gleason, Melancon, & Keline, 2010). Liras and Arenas (2010) stressed that scientific knowledge and its credibility should essentially stem from the need for its impartiality and objectivity and the force it exerts should be based primarily in building citizen's capacity to solve social problems. In exposing learners to socio-scientific issues, it is expected that they initiate the dissemination of knowledge objectively with few ethical dilemmas influenced by their own ideologies or pressures (Liras & Arenas, 2010). The results of this study show enhancement in the scientific literacy of students by having reasoned arguments on socio-scientific issues.

In Table 2, results of the independent samples *t*-test on the DMSS show no significant difference in the mean pretest scores of the SSI Group and the Conventional Group which indicates comparability of the two groups in terms of academic performance. As hypothesized, the mean posttest scores show that there was a significant difference in the performance of the two groups in favor of the SSI Group ($M = 22.39$, $p = .00$). This means that integrating socio-scientific issues in science classes significantly improves the bioethical decision-making skills of students. In this study, it is clear that since students were trained to make constant decisions in most of the activities they were asked to do, the values necessary to shape their behavior eventually led them to positive cognition.

Table 2. Independent samples *t*-test for the pre- and posttest scores for the Decision-Making Skills Survey (DMSS)

Measure	Group	Mean	SD	df	*t*-ratio	Sig. value (*p*-value)
Pretest	SSI Approach	11.03	2.51	72	1.29	.202
	Conventional	10.39	1.65			
Posttest	SSI Approach	22.39	1.78	72	10.78	.000
	Conventional	18.29	1.49			

Coles and Norman (2005) presented that values developed in the practice of decision-making have an important influence on students' behavior. Decisions are likewise influenced by preferences, opinions, emotions, and culture characteristics (Mettas, 2011). Students in this study reacted to socio-scientific issues based on how those issues affected their lives. Moreover, how the teacher processed previous events in the classroom played a very important role in making students more engaged in their classroom activities.

In a "typical" decision-making process, a subject is presented with a brief decision-scenario (e.g., description of medical problem) and decision-makers are required to select a course of action from a set of fixed alternatives. Prior to this study, this decision-making process is predetermined not to be restrictive of the varied possible ways so that students can exercise their skills in stating their opinions on issues they are presented with. It is more of a descriptive approach to decision making where all opinions were accepted from students' responses with an aim to arrive at a unified decision. Through this approach, students became more open and confident in communicating their opinions. This explains therefore the positive effects of the intervention on the students' performances. This also supports the study of Pomahac, Gunn, and Grigg (2007) that socio-scientific issues can establish deeper critical thinking and respect of the diversity of opinions among students when they are free to express themselves. Moreover, this supports the study of Quitadamo, Brahler, and Crouch (2009) that when group work is applied in most of the classroom activities, students' performance were enhanced as they had the opportunity to solve problems in an interactive manner.

Results of the related sample *t*-test on the mean scores of the DMSS show significant difference on the mean pre- and posttest scores of the two groups. From Table 3, it is clear that socio-scientific integration had a positive result on the decision-making skills of the students as indicated in the significant increase in their mean scores after the intervention. Most importantly, the mean score of the SSI Group (M = 22.39) was significantly higher than that of the Conventional Group (M = 18.29).

Table 3. Related samples *t*-test for the pre- and posttest scores for the Decision-Making Skills Survey (DMSS)

Group	DMSS Pretest	DMSS Posttest	Standard Deviation	Standard Deviation	df	*t* ratio	Sig. value (*p*-value)
	Mean	Mean	Pretest	Posttest			
SSI Approach	11.03	10.39	2.51	1.65	35	24.00	.000
Conventional Approach	22.39	18.29	1.78	1.49	37	23.43	.000

In this study, socio-scientific issues were integrated in the SSI Group through various ways such as argumentation or debate activities, case analyses, and moral games to enhance students' decision-making skills. Through these methods, rote learning and teacher-centeredness were minimized and students were made more responsible and aware in dealing with biological issues. Students were made to understand the rational basis of their decisions addressing the aim of science education which is to reduce the acceptance of unwarranted claims.

During the early classroom sessions, it was observed that students were slightly passive but as the intervention went on, they openly communicated with their teacher leading to an active learning environment. This can be attributed to the teaching approaches used wherein the teacher allowed maximum participation of the students in expressing their views. This reaffirms the claim of Yahya, Sidek, and Jano (2011) who said that through constant interactive activities in class, students had enough time to actively engage in the learning process. Moreover, Berland and Hammer (2012) said that students become more active in expressing their views than expected if they are provided with enough opportunities inside the classroom. The social interaction between and among the students had a positive effect on the development of the decision-making skills of students. In fact, Van Amburgh, Devlin, Kirwin, and Qualters (2007) claim that in this teaching approach, students were trained to manage their own opinions and develop the ability to work collaboratively with enough consideration of others' opinions.

In an inquiry-based classroom, teachers must adopt a realistic view of science in order to create a connectin between the ideas of sciene and the stduents' actual experiences. This can be done if the teacher presents the lesson in varied ways that encourage critical thinking and deeper discussions. In this study, the teaching methods used were augmented by the teacher's questioning skills. Moreover, the teacher extended the 'wait time" for students to express the answers and opinions on issues presented to them. Acoording to Cazden (2001), teachers who extended wait times in between questions significantly benefitted students in ways such as: 1) students giving longer and elaborate responses, 2) students giving a wide range of evidences for their ideas and conclusion, 3) students speculating and hypothesizing more, and 4) students asking more questions and talking more to each other. This aligns Kerry's (2002) claims that questions play important role in the processes of teaching and learning and that students' achievement and their level of engagement depends on the types of questions teachers formulate. It is therefore important that teaching and learning be set to a social activity where teachers and students construct and synthesize knowledge mutually through active processing, thinking about, and using information productively (Mauigoa-Tekene, 2006). In this study, teachers' questions facilitated students' learning. Questions mediated the interactive processes in the learning environment in a number of important ways especially when these served as cues and clues for students to critically think.

This study also highlighted the importance of the content knowledge of the biology teacher and her ability to recognize timely socio-scientific issues which can be integrated in the lesson. With sufficient content knowledge, the teacher carefully planned appropriate questions before implementation which facilitated the students' learning experiences in an interactive way.

4. Conclusion

In this study, the aim to make students more aware and make decisions on the impacts of science was achieved. The use of relevant and authentic socio-scientific issues encouraged and allowed students to actively evaluate both the advantages and disadvantages of science in their lives. The various teaching strategies employed by the teacher led the students to evaluate their perceptions on scientific breakthroughs through collaborative and reflective thought-sharing activities which enhanced their scientific literacy. Integrating socio-scientific issues can therefore be a timely approach to enhance the bioethical decision-making of high school students. This expands the strategies in science education to be taught in a proactive manner focusing on the enhancement of students' decision-making skills.

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