科學教育學刊
2017, 第二十五卷第四期, 391-412
DOI: 10.6173/CJSE.2017.2504.04

Chinese Journal of Science Education
2017, 25(4), 391-412

Exploring University Students' Group and Individual Socioscientific Decision Making with Web-Based Instruction

Su-Chi Fang and Ying-Shao Hsu*
Graduate Institute of Science Education, National Taiwan Normal University

Abstract

In this study, we designed a web-based learning environment about water resources to support students' socioscientific decision making. The purposes of the study were to analyze and compare undergraduate students' interdisciplinary thinking and decision making at the individual and collective levels. Individual students first completed the web-based learning unit at home, in which they needed to decide on a suitable location for building a dam. Then, they worked in groups, discussing, debating, and negotiating to reach a group decision. Individual interdisciplinary thinking and decision making were recorded by the web-based platform. Group discussions were audio- and video-taped. Interdisciplinary thinking was analyzed qualitatively based on the SEE-SEP framework. Decision-making approaches were examined and categorized into different proficiency levels. The results show that, compared to individual decision making, the students used more moral or ethical considerations and made more links to personal experiences when engaged in group discussion. Despite wider aspects being considered at the group level, some facets such as their beliefs, values, and experiences regarding science were not adopted in the arguments at either the individual or the group level. Although a few students were able to use compensatory strategies when making individual decisions, none of the groups employed compensatory strategies to reach a group decision. The comparison between individual and collective levels manifests that group discussions can facilitate interdisciplinary thinking. The deficiencies in the group decision making identified in the study such as lack of deep reflection and not using a refined decision-making strategy underscore the need to provide scaffolds for collective decision making.

Key words: Decision Making, Socioscientific Issues, Web-Based Learning Environments

Introduction

In modern societies pervaded with the products of science and technology, socioscientific issues are expanding and playing an increasingly more influential role in people's lives. Developing scientifically literate citizens who are able to use evidence-based reasoning and make informed socioscientific decisions has thus become one of the significant learning objects in science education (Evagorou & Osborne, 2013; Zeidler, Sadler, Simmons, & Howes, 2005). Promoting students' socioscientific decision-making competences in science education subsumes multiple purposes at different levels. Students are expected to compre-

* Corresponding author: Ying-Shao Hsu, yshsu@ntnu.edu.tw
(Manuscript received: May. 24, 2017; Revised: Aug. 29, 2017; Accepted: Aug. 29, 2017)

hend the issue and take appropriate actions at the personal level, be able to provide fair judgement of how this issue is handled by the authorities at the local level, and be capable of following the public debate on the issue at the national or global level. All of these intended purposes involve not only individuals but also groups of people. Therefore, to enhance students' competences in socioscientific decision making, it is necessary to consider and look into both individual performances and group interactions and decisions (e.g., Aikenhead, 1985; Eggert & Bögeholz, 2010; Gresch, Hasselhorn, & Bögeholz, 2017; Jho et al., 2014).

Significant efforts have been made to explore and facilitate students' socioscientific decision- making competencies. Most of the previous research has been concerned with individual students' learning performance as well as the effectiveness of innovative instructional designs. The findings showed that engaging students in socioscientific issues could help deepen their conceptual understanding of scientific knowledge and enhance their higher-order thinking skills, such as informal reasoning, argumentation, and decision-making skills (e.g., Grace, 2009; Gresch et al., 2017; Jiménez-Aleixandre, 2002; Siegel, 2006; Wu & Tsai, 2007; Zohar & Nemet, 2002). Some studies have been interested in the social interactions involved in the decision-making process. They have suggested using socioscientific issues as scenarios to drive and enthuse students to engage in meaningful discussions (Levinson, 2008) and have identified the characteristics of high-quality discussions during group activities (Grace; Ratcliffe, 1997). Despite the useful insights provided by the previous research, little is known regarding students' socioscientific decision making at a collective level, that is, how individuals present, communicate, and integrate various ideas within groups and how a group of people negotiate, compromise, and reach a final decision. To address the research gap presented in the literature, the current study explored undergraduate students' individual and collective interdisciplinary thinking and decision making in the socioscientific scenario of water resources. As previous research has argued that schools provided scarce opportunities for students to link school-based scientific knowledge to socioscientific setting (Jho et al., 2014; Wu & Tsai), the study adopted a web-based platform with embedded scaffolds to support students' selection and connection of relevant scientific knowledge to the socioscientific setting.

Literature Review

Socioscientific issues are open-ended, ill-structured, and complex real-world science problems. Although these issues are rooted in science, they are tightly associated with social, environmental, political, economic, and moral concerns (Sadler, 2004). In addition, there is no definite solution to these problems. Multiple solutions with their respective advantages and disadvantages are juxtaposed and open for debate. Decision making is a process meaning "the making of reasoned choices" from different alternatives based on one's values regarding a personal or public issue (Kortland, 1996, p. 675). Making decisions on socioscientific issues, that is socioscientific decision making, can thus be understood as a series of recursive processes involving searching for and evaluating various kinds of information, reasoning from multiple perspectives, considering the pros and cons of alternative options, and positing a suitable decision-making strategy to reach a final decision (Eggert et al., 2013; Papadouris, 2012).

Interdisciplinary thinking in socioscientific decision making

Socioscientific issues are complex and controversial in nature. Different people or groups have divergent views, different values, and use different information resources. Therefore, logical but conflicting arguments in relation to the issues can be constructed from multiple perspectives. To be able to tackle the complexity, one needs to first be aware of the variety of information, integrate different perspectives, and reason about the issue in a more holistic manner. The term interdisciplinary thinking is used to describe the aforementioned thinking skills. It denotes "the capacity to integrate knowledge and modes of thinking in two or more disciplines" (Liu et al., 2011, p. 499).

Researchers have conducted studies to explore students' interdisciplinary thinking when encountering socioscientific issues. Focusing on an environmental management issue about an exotic plant species, Liu et al. (2011) classified the college students' responses into several categories: ecological, ethical, aesthetic, scientific technological, and social economic perspectives. The results showed that about half of the participants made decisions relying on simply one single disciplinary viewpoint, one third used two reasoning modes, and only a few were able to integrate various ideas from more than three disciplines. In other words, it appeared that many of the college students did not perform interdisciplinary thinking when facing the socioscientific issue. Wu and Tsai (2007) used open-ended questionnaires to explore Grade 10 students' informal reasoning on the issue of nuclear energy usage. They categorized the students' arguments into four fields (social-oriented, economic-oriented, ecological-oriented, and science-oriented or technological-oriented) and analyzed their total number of reasoning modes. The findings indicated that, on average, the students adopted more than two reasoning modes. In line with the research by Yang and Anderson (2003) and Sadler and Zeidler (2005), this research demonstrated that upper secondary students did possess interdisciplinary thoughts and were able to reason the issue from various perspectives. Although previous research on students' ability to adopt interdisciplinary thinking in socioscientific decision making showed distinct findings, the researchers all emphasized that to improve quality socioscientific decision making, it is critical to include an instructional design that ensures students are aware of and are reasoning from multiple perspectives (Kolstø, 2006; Wu & Tsai). Apart from disciplinary areas, relevant studies have also pointed out that students frequently use personal experiences and rely on their values and attitudes when constructing arguments in socioscientific contexts (Acar et al., 2010; Albe, 2008; Bell & Lederman, 2003).

Chang Rundgren and Rundgren (2010) proposed a model named SEE-SEP which includes three aspects (knowledge, value, and experiences) and six subject areas (sociology/culture, economy, environment/ecology, science, ethics/morality, and policy) to portray the many-faceted nature of socioscientific issues. The six letters S-E-E-S-E-P stand for the six subject areas. The combinations of the three aspects and six subject areas create 18 codes, and help researchers to comprehend the socioscientific issues from a multidisciplinary viewpoint and in a more holistic manner. Previous research has shown that the SEE-SEP model is fruitful for analyzing and depicting students' interdisciplinary thinking. The model not only helps to link between the aspects of knowledge, values, and experiences, and the six subject areas, but also allows systematic categorization of the resources students draw upon in their justifications (Christenson, Chang Rundgren, & Zeidler, 2014; Christenson, Chang Rundgren, & Hoglund, 2012). Thus, this study employed the SEE-SEP model to examine how students might perform interdisciplinary thinking at individual and collective levels.

The use of decision-making strategies in socioscientific decision making

Unlike everyday routine decisions such as deciding where to turn right on the way home, decision making in socioscientific contexts cannot be solved spontaneously or be merely based on intuition. Instead, one has to appraise and judge related information, and compare available alternatives in order to make a final choice. The literature suggests three decision-making strategies that learners may use in socioscientific contexts: non-compensatory, compensatory, and mixed methods (Böttcher & Meisert, 2013; Gresch, Hasselhorn, & Bögeholz, 2013). A non-compensatory strategy expresses the situation in which one uses some criteria as knockout criteria. The options that do not meet the criteria are eliminated without considering other advantages. This procedure is repeated until only one option is left. A compensatory strategy, that is, the use of trade-offs, is deemed a critical ability for making informed decisions. The features of performing a full trade-off are to consider and compare the pros and cons of multiple options. The overall quality of each option is appraised based on the information provided. It is worth noting that different criteria may be given different weights. Consequently, important criteria, that is, the criteria with greater weighting, will have a greater influence on the final decision compared to less important criteria. The third strategy, the mixed method, combines non-compensatory and compensatory strategies. In using this strategy, one first uses some criteria to screen and exclude unsatisfactory options and then performs a full trade-off to evaluate the remaining options. Eggert and Bögeholz (2010) used the Rasch partial credit model to determine a progression in decision-making behavior, that is, from rather intuitive (the use of non-compensatory strategies) to more refined (the use of compensatory strategies) decision making.

Papadouris and Constantinou (2010) explored sixth-grade students' decision-making behavior in the contexts of selecting the most suitable place for a desalination plant or an electricity power station. Their findings suggested that students had difficulties consistently applying coherent decision-making strategies. Two types of instructional interventions regarding decision-making strategies have been suggested in the literature: (1) introducing three decision-making strategies and guiding students to select a useful strategy for a specific situation (Gresch & Bögeholz, 2013; Gresch et al., 2013) and (2) introducing simply one optimum decision-making strategy and training students to use the strategy appropriately (Papadouris, 2012). The two interventions have been proved to be beneficial for supporting students to process relevant data effectively. Nevertheless, these studies all implied that to apply decision-making strategies meaningfully, it is crucial for students to truly understand, appreciate, and reflect on the strategy itself and why it is useful for decision making.

Collective interdisciplinary thinking and decision making

In real life situations, socioscientific issues are never situated in an individual setting. Engaging in these issues implies discussions and dialectical argumentation among people and groups by which they collectively debate for and against favored standpoints (Nielsen, 2012). In science classrooms, socioscientific instruction usually engages students in group discussions. Some studies have shown that group discussions can help broaden students' views on the socioscientific issue and provoke reflections on their own perspectives. This is particularly helpful when exposing students to their counterparts from various cultural contexts (Grace, Lee, Asshoff, & Wallin, 2015; Lee & Grace, 2012). Grace et al. and Lee and Grace conducted studies comparing socioscientific decisions made by secondary students from different contextual settings. The findings showed that the students with different cultural backgrounds presented varied reasoning perspectives, and selected distinct decision-making criteria and evidence. Having students across different settings share their arguments and decisions seemed to be fruitful for widening perspectives and stimulating metacognitive reflection on individuals' viewpoints and values. Christenson et al. (2014) compared the socioscientific argumentation practices of upper secondary science major and social science major students. Their results indicated that students with different majors were inclined to generate justifications from diverse subject areas and aspects (knowledge, value, experience). Therefore, engaging students as well as teachers from different disciplines may enrich and facilitate socioscientific teaching and learning. In addition to prompting wider views and metacognitive reflection, peer interactions during the decision-making process can stimulate students' deeper processing of information, promote higher-order thinking skills, and develop robust knowledge (Eggert et al., 2013). Ratcliffe (1997) examined 15-year-old pupils' decision-making written work and their group discussions using a six-step decision-making structure. She identified several crucial features to characterize informed and thoughtful group decision making. Including group members who are able to consider different options, who can help focus discussions with explicitly defined criteria, and who are willing to contribute and ponder over both their own and other members' viewpoints, is likely to contribute to well-informed group discussion and decision making.

The review of the research in relation to interdisciplinary thinking, decision-making strategies, and group interactions provided fruitful insights into the implementations of socioscientific decision making. Although most of the studies employed group discussion as an instructional approach during socioscientific learning, relatively little research has explored students' interdisciplinary thinking and decision making at a collective level or has compared students' socioscientific decision making at the individual and collective levels. As foreshadowed in the previous section, decision making involves not only individual action but also collective interactions and decisions. Collective socioscientific discussion and decision making are influenced by the assorted perspectives students bring to class. It is pivotal to investigate how students' perspectives or orientations may influence how they communicate and frame their decisions in socioscientific contexts (Balgopal, Wallace, & Dahlberg, 2017). To address the research gap identified from the literature, the aim of this study was to explore undergraduate students' collective interdisciplinary thinking and decision making in a socioscientific scenario regarding water resources. Specifically, we asked two research questions:

(1) Regarding a socioscientific scenario about water resources, what are the similarities and differences in the undergraduate students' interdisciplinary thinking at the individual and collective levels?

(2) What is the nature of the undergraduate students' collective decision making regarding a socioscientific scenario about water resources?

Methods

Context

This study was conducted in an undergraduate core course: Human and Natural Resources. We designed a three-session core curriculum (2 hours per session, 1 session per week) on the topic of water resources that aimed to support undergraduates developing interdisciplinary thinking and decision-making abilities. The first two sessions were lectures using slides to introduce important worldwide issues pertaining to water resources, such as global water scarcity, water pollution, and water sustainability. Then, individual students were required to complete a socioscientific online learning unit (Figure 1) as homework before attending the third session.

In the third session, the students worked in groups. Each group was given a notebook to assess the online learning unit and discussion guide. In brief, the group members were required to first share their individual perspectives and deliberations when deciding on the dam location. Second, they had to describe their own decision-making processes. Third, they were asked to discuss and negotiate a group decision. Lastly, each group presented to the whole class how and why the group decision was reached.

The socioscientific online learning unit

This online learning unit is constructed on the Collaborative Web-based Inquiry Science Environment (CWISE), a computer-based learning platform originally developed by the University of Berkeley (WISE) (Linn & Eylon, 2011). The purpose of using the learning platform was to create a learning environment with integrated scaffolds for supporting students' socioscientific learning. Specifically, the learning environment presented authentic data for location comparisons, posed questions to guide evidence-based reasoning, and incorporated visualization tools to simulate consequential situations.

This online learning unit consists of a decision-making strategy training part and a guided decision-making task. Using the selection of a mountain bike as the scenario, the training part guided students to summarize and reflect on the three different decision-making processes, through which three types of decision-making strategies, including one non-compensatory procedure and

Figure 1. Screenshot of the “Data Center” in the online socioscientific learning unit on CWISE

two compensatory procedures: scoring and weighting, were introduced. The guided decision-making task was developed based on a decision-making framework that involved three stages: recognizing the decision problems, differentiation, and post-decision consolidation (Hsu & Lin, 2017; Svenson, 1992). The socioscientific scenario required the students to decide on a dam location from six options. During the task, they were guided to generate and elaborate on criteria for selecting the dam location, analyze data collected from the data center, compare the pros and cons of the different options, apply a decision-making strategy to make a decision (Hsu & Lin).

Participants

Students with various majors freely enrolled in this core course. A total of 38 students who attended the third session of the curriculum were invited to participate in the study. They were randomly assigned to eight groups: GP1 to GP8. Each group had four to five students. Due to limited resources, data collection and analysis were focused on GP1 to GP6, encompassing a total of 28 students (16 science-major students, 12 social-science-major students).

Data collection and data analysis

Each individual student’s written responses in the socioscientific learning unit (homework) were recorded by the web-based learning platform. These responses were used to inform individual students’ interdisciplinary thinking (step 4.3) and decision making (step 6.2). Specifically, in step 4.3 (Figure 2), the students were required to list the criteria they considered and explain the reasons why they included these criteria when deciding on a dam location. Analyzing the students’ responses in step 4.3 helps us understand which dimension (subject areas) and what resource (aspects) they draw upon in the socioscientific decision-making process. Step 6.2 (Figure 3) asked students to write

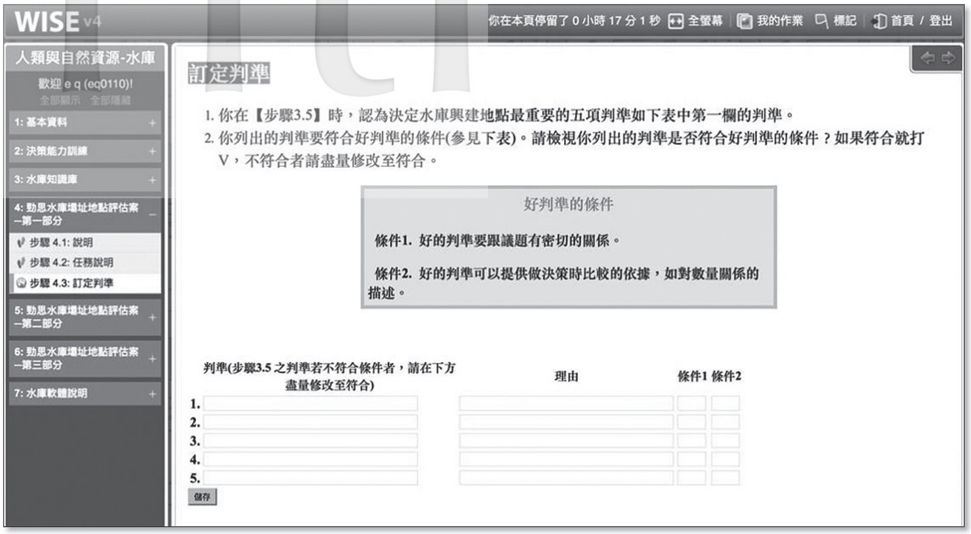

Figure 2. Screenshot of step 4.3 in the online socioscientific learning unit

down their thinking process about how they managed to compare the options based on the information provided and how they reached their final decision. Students' explanations in step 6.2 thus represented the decision-making strategy adopted at the individual level. Group discussions and presentations in the third session were audio- and video-taped. Group discussions were transcribed verbatim for analysis.

Individual student and group interdisciplinary thinking were examined based on the SEE-SEP framework developed by Christenson et al. (2014). The codes for subject areas enable identification of the content students draw upon in their own thinking processes or group discussions. The three aspects: knowledge, value, and experiences, were ad-

Figure 3. Screenshot of step 6.2 in the online socioscientific learning unit

opted to determine the resources the students used in their reasoning and decision-making processes. Combining the six subject areas with the three resource aspects generates 18 codes in the SEE-SEP framework that help describe and understand the students' interdisciplinary thinking in this complex socioscientific setting. Table 1 shows the definition for each code based on Christenson et al. and some examples from individual responses or group discussions. In the study, none of the students' arguments pertained to the subject area "policy," so this subject area was excluded from the analysis. Regarding decision-making abilities, the individual and group decision-making approaches were analyzed and classified into different proficiency levels based on Eggert and Bögeholz's (2010) work. A score of 0 was given for no answer or for using an invalid decision-making strategy. Scores of 1 and 2 were given for the use of a non-compensatory (knockout) approach implicitly or explicitly prioritizing the criteria, respectively. A score of 3 was given for the use of compensatory approaches. Table 2 provides the scoring guide and some examples.

The interrater reliability was addressed through two steps. First, according to the SEE-SEP framework and the definition for each code, the first author and the other researcher (a well-trained master's student) coded and scored all of the individual students' responses in step 4.3 and step 6.2 respectively. After that, they further clarified the meanings of the codes using students' responses. Then they compared the codes/scores and discussed all of the discrepancies in order to reach agreement. The first step, on the one hand, gave consistent codes/scores to the students' individual interdisciplinary thinking and decision making. On the other hand, it helped enhance the consistency and alignment of the interpretations of the codes/scores of the two raters. In the second step, two groups were randomly selected from the six group discussions. The transcripts of the two group discussions were coded by the two raters respectively. The agreement between the two raters for coding the group discussions reached an acceptable level of 75%.

Results

This section reports the research findings regarding the similarities and differences between the undergraduates' individual and collective interdisciplinary thinking and decision making.

Individual and group interdisciplinary thinking

Regarding individual interdisciplinary thinking, most of the students (22/28) were able to consider the socioscientific issues from three or more subject areas and provide coherent arguments. A total of 108 arguments were generated by the 28 students in their individual responses. In general, Science (54%), Sociology/Culture (23%), and Environment (19%) were the most frequent subject domains taken into account when deciding where to build a dam. For each domain, the students often drew upon the knowledge aspect to justify their decisions (72%) related to scientific concepts or referred to the data obtained from the online learning environment) rather than making value statements (28%) or referring to previous experiences (none). With respect to the collective level, interdisciplinary thinking was strikingly evident in the group discussions. That is to say, these students tended

Table 1. The definitions of codes and some examples from individual responses or group discussions

Codes	Definitions	Examples
SoK	Students provide concepts or theory from sociology/culture to support their arguments	• There will be safety concerns if there are villages around the area. (GP1-2) • People who live in the catchment area need to be moved. (GP2-1)
SoV	Students make connections of value/affect/attitude from the subject area of sociology/culture	• Historical monuments cannot be repaired once they are destroyed. (GP1-4) • The dam cannot be built in the places with historical monuments. You cannot destroy historical monuments arbitrarily in order to meet people's needs. (GP2-5)
SoE	Students use their experiences from the subject area of society or culture to support their arguments	• In previous geology lessons, we learned about the construction of The Three Gorges Dam in China. There were a lot of people being relocated because of building the Dam. (GP5)
EcK	Students provide concepts or theory from the economics subject area to support their arguments	• The lifespan of the dam is short, but the costs for maintaining it is much more than that for number 5. (GP2) • Whether or not the dam has sedimentation problem needs to be considered. If the problem exists, the lifespan would be very short and the maintenance fee would be higher. (GP3-3) (in combination with ScK)
EcV	Students make connections of value/affect/attitude from the subject area of economics	• We need to consider whether or not the water in the catchment area is polluted. To clean the water and to solve the problems about water pollution would cost a lot of money. (GP6-1) (in combination with ScK)
EcE	Students use their experience of economics to support their arguments	• I think Taiwan has rich water resources. I rent an apartment, and I did not pay much for water usage. Compared to Hong Kong, this is much cheaper. (GP4)
EnK	Students provide concepts or theory from ecology/environmental science to support their arguments	• The ecology is destroyed. Also, this will endanger those endemic species. (GP1-1) • The construction of the dam will damage the natural environment around the area. (GP1-2)
EnV	Students make connections of value/affect/attitude from the subject area of ecology/environmental science to support their arguments	• Once the natural environment is destroyed, it cannot be recovered no matter how much money you have. (GP2-1)
EnE	Students use their experiences of ecological/ environmental science to support their arguments	• I learned from the news that if the dam has too much sedimentation, like Shihmen Dam or Zengwen Dam. My high school teachers also talked about this. The water storage would be much smaller, and the dam will have to be moved. (GP4)
ScK	Students provide concepts or theory from science (i.e., biology, chemistry, technology, medicine, etc.) to support their arguments	• Large water catchment area. The places where rivers merge can bring more water into the dam. (GP1-1) • Whether or not the fault line passes here. If the dam is built on the fault line, the shaking of the earth surface will bring serious damages. (GP1-2)
ScV	Students make connections of value/affect/attitude from the subject area of science to support their arguments	• N.A.
ScE	Students use their experiences from the subject area of science to support their arguments	• N.A.
EtK	Students provide concepts or theory of ethics/morality to support their arguments	• N.A.
EtV	Students make connections of value/affect/ attitude from the subject area of ethics/morality to support their arguments	• If we decide to build a dam at No.5 or No.6⋯ How can they make a living if all of the villagers are on miners? (GP2) • 700 households⋯ It would be OK if they are young people. How can you⋯ it would be very difficult if most of them are elderly people. (GP5)
EtE	Students use their experiences of ethics/morality to support their arguments	• N.A.

Source: "The relationship of discipline background to upper secondary students' argumentation on socioscientific issues," by N. Christenson, S.-N. Chang Rundgren, & D. L. Zeidler, 2014, *Research in Science Education*, *44*(4), 581-601.

Table 2. The scoring guide for students' decision-making strategy at different proficiency levels

Score	Scoring guide	Example
0	Did not answer or used an invalid decision-making strategy	GP4-2 The priority is not to influence people and things. The location needs to be far away from the fault line. You can repair it if there are some damages.
1	Used a non-compensatory approach: implicitly prioritized the criteria	GP3-4 The impacts on the natural environment (need to consider economic development at the same time). Find the dam location where can benefit the most of people. Do not move a lot of people because of flooding. Consider geology and the place to build the dam. Do not select the place with landslides or crossed by fault lines.
2	Used a non-compensatory approach: explicitly prioritized the criteria	GP3-1 First, whether or not there are fault lines around the location is my number 1 criterion. Because they can destroy the dam in a second. So, No.3 is eliminated. Then, we need to choose a location with larger water catchment area. Also, not many important plants or animal are around. From Step 5.1, we know that there are no historical monuments there. No.4 has too many roads passing by. It has many landslides, so it is excluded. No.2 and No.5 are left. There are historical monuments in Location No.2. Also, more people need to be moved. The water storage is smaller compared to No.5. So the final decision is No. 5.
3	Used a mixed or compensatory approach	GP2-4 The reasons why I selected the dam location No. 3: 1. I selected some relevant criteria to evaluate these locations: rivers, historical monuments, fault lines, geological map, landslides, and villages. 2. I eliminated the locations depending on the criteria: I excluded the locations with 2 or more "No". The geology features are not appropriate in locations No. 5 and 6. No.1 and 2 have smaller water catchment areas. 3. I eliminated the locations depending on the importance of the criteria: No.3 and No.4 are left. No.4 has too many villages. So, No.3 is the final decision.

to look at this issue from wider subject areas and drew upon different source aspects when involved in group interactions. Similar to the individual responses, the most used subject areas by the groups were Science (26-52%), Sociology/Culture (21-36%), and Environment (12-37%). The students adopted all of the three source aspects to back up their arguments (knowledge 44-91%, value 4-46%), experience (2-16%).

Figure 4 shows a comparison of the interdisciplinary thinking in the individual responses and group discussions using the perspective of the SEE-SEP framework. It is noted that during the individual decision-making process, none of the students presented ethical considerations (subject area Et: Ethics/Morality). However, in the group conversations, five of the six groups expressed and articulated their moral concerns pertaining to the issue. For example, the students in GP5 argued that it was inhumane to force elderly people to move away from their hometown just because the government decided to construct a dam there. GP2 stated that if all of the villagers were miners (the village was in one of the dam locations), it was impossible for them to make a living if a dam was going to be built in this area. One student in GP4 mentioned that a total of 700 people had to move if they decided to build a dam at location 4. As 700 is indeed a large number of people, it would be a tragedy for them to move away from their home. While none of the students in GP2 and GP5 wrote down economic viewpoints during their individual decision making, these two group discussions considered the expense and incorporated economic perspectives into their deliberation. For instance, GP5 calculated how much money would be left af-

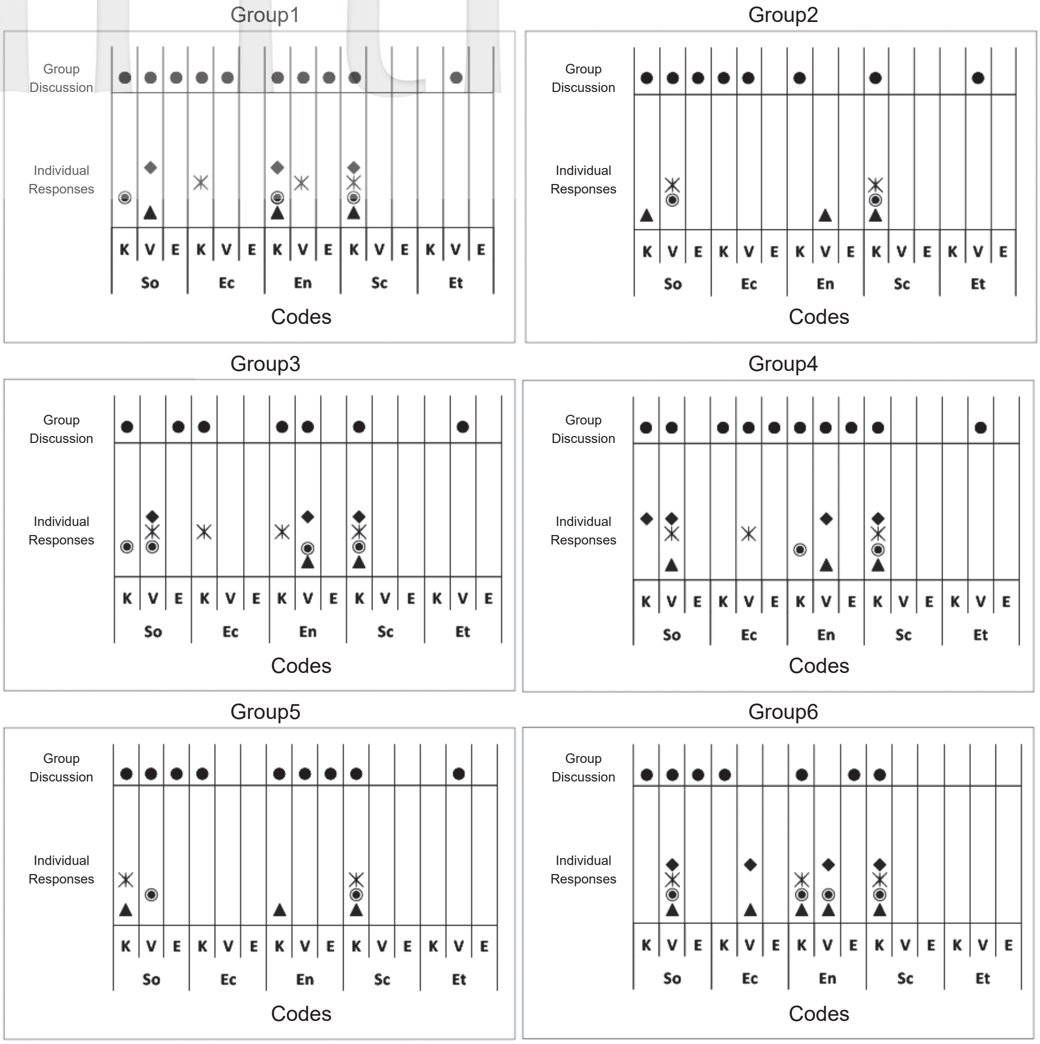

Figure 4. Individual and collective interdisciplinary thinking in the different subject areas and aspects

Note: So: Sociology/Culture; Ec: Economy; En: Environmet/Ecology; Sc: Science; Et: Ethics/Morality; K: Knowledge; V: Value; E: Experience

ter building the dam and compared the expenditure of maintaining the dams for the different options. The GP2 students compared the costs of removing silt and expressed that they would select the location with lower costs.

In addition to covering more subject areas, the comparison between individual and collective interdisciplinary thinking indicated that when involved in peer interactions, students were more likely to use their experiences to support their arguments (the aspect of experience). The GP5 students recalled a famous controversial case of building a dam: The Three Gorges Dam, and indicated that thousands of archaeological sites were flooded during the construction and that these cultural and historical relics could never be recovered. One of the students in GP4 was from Hong Kong; she expressed that from her experience, the cost of water usage in Taiwan was much cheaper than in Hong Kong. She argued that Taiwanese people needed to reconsider if it was necessary to construct a new dam. Perhaps it was more important to educate people that water is a precious resource. One student from the same group also mentioned that in a television program, he learned that dams actually have a limited lifespan. If a dam is not well maintained, it has to be removed one day.

In sum, the results demonstrated that, compared to individual interdisciplinary thinking, the students were inclined to adopt a greater variety of subject areas and aspect resources to support their arguments during the group discussions. When involved in group interactions, the students were likely to express affect, articulate positive or negative comments, give value statements, and make connections to previous learning or life experiences. However, the analysis also revealed that some of the dimensions of seeing the socioscientific issue were not shown at either the individual or the collective level, such as making arguments by linking personal value/affect/attitude to the subject area of science (ScV), using experiences from the subject area of science (ScE), using concepts/theory of ethics (EtK), and employing personal experiences that related to ethics/morality (EtE).

Individual and group decision making

Pertaining to individual decision making, the majority of the students (16/28, 57%) used a non-compensatory approach to make their decisions. These students listed the criteria selected, considered one criterion at a time, and eliminated the option(s) that did not meet the criterion. Some of them explicitly expressed their priority for the criteria (11/16, see Table 2, score 2), while the others determined their priority implicitly (5/16, see Table 2, score 1). A few students (7/28, 25%, see Table 2, score 3) adopted a compensatory decision-making strategy that systematically compared and weighed the pros and cons of the different locations. They gave each criterion different weights or scored each dam location based on the extent to which it could fulfill the criterion.

At the collective level, the six groups adopted distinct group decision-making approaches. Although most of the groups exchanged and shared their perspectives, discussed each other's considerations, and compared and contrasted the alternatives according to certain criteria, none of them applied a sophisticated compensatory approach to reach an informed group decision. Two types of group decision-making approaches were identified from the six groups. GP1, GP3, and GP6 adopted limited group decision-making approaches, whereas GP2, GP4, and GP5 used partial decision-making approaches (see Table 3).

GP1, GP3, and GP6 did not take all of the six options into account during the group decision making. These three groups simply selected two options that were decided by their group members, and made their group decision based on the two pre-determined alternatives. The summary and analysis of the group discussions showed that GP1 and GP3 made group decisions intuitively. The group members talked about the criteria they contemplated, explained how they excluded some of the options, stated their perspectives, and discussed their considerations; however, they did this in a random and unsystematic way. Fundamentally, these two groups made the final decision based on an overall impression of the pros and cons of

Table 3. Two types of group decision-making approaches emerged in the study

GP1, GP3, GP6	GP2, GP4, GP5
Limited Group Decision-Making Approaches	Partial Group Decision-Making Approaches
• All made group decisions between two pre-determined alternatives. • GP1 and GP3 made group decisions intuitively. • GP6 examined the pros and cons of the two choices based on a few criteria and used a cut-off approach to reach their group decision.	All three groups: • Excluded the location(s) with safety concerns (cut-off strategy). • Agreed on several criteria and collected data using the data center and simulations. • Compared the strengths and weaknesses of the options, and made group decisions with implicit and ambiguous priorities.

the options instead of performing full trade-offs (see Table 4). Similar to GP1 and GP3, GP6 made their group decision based on three pre-determined options: locations No. 3, 4, and 5. Because of landslides and many people needing to be relocated, No. 4 was eliminated. The students then examined the pros and cons of the remaining two choices based on a few criteria and used a cut-off approach to reach their group decision.

Compared to the other three groups, GP2, GP4, and GP5 had richer discussions about each group member's perspectives and adopted thorough decision-making approaches. These three groups shared several common features. They first used some knockout criteria to exclude unsatisfactory location(s) (cut-off strategy). Then, based on several criteria that were agreed to be important, they collected data using the data center and sim-

Table 4. A summary of GP1's group discussion and decision making

Time	Transcript Numbering	Discussion Theme
0:01.00–0:04.44	1-14	Group members read discussion guide and chatted.
0:04.46–0:21.39	15-361	Group members randomly expressed their decisions and decision-making processes. The criteria discussed in the conversations: • Lifespan of the dams • Silt problems of the dams • Flood ancient monuments • Destroy natural environment • Expenditure of building a dam • Affect ecological balance • Do harm to Aboriginal people
		Group Decision-Making
0:24.23–0:30.14	362-545	Compared locations No. 5 and No. 6 Group members discussed pros and cons of location No. 5. • No.5 (Pros) No ancient monuments nearby. • No.5 (Pros) Non-threatening to natural environment. • No.5 (Pros) Not close to faults. • No.5 (Pros) Larger catchment area. • No.5 (Pros) Longer lifespan. • No.6 (Cons) Damage endangered species. • No.6 (Pros) No ancient monuments nearby. • No.5 and 6 (Cons) Landslides
0:30.16–0:47.41	546-971	Group members went online to run simulations for locations No. 5 and No.6. They found these two locations were similar, but location No.6 would have negative impacts on the natural environment. So, the group decided to select No. 5.
0:48.00–0:51.16	972-1016	Group members made a poster for presentation.

ulations in the online learning unit. The groups talked about the strengths and weaknesses of the options regarding the criteria, and made their group decisions with implicit and ambiguous priorities. Taking GP4 as an example (see Table 5), the first knockout criterion they adopted was water storage capacity. Locations 1, 5, and 6 had larger water storage capacity so they were selected. Then, location 1 was eliminated because it was very close to a fault line. Following that, the group members spent some time going through the advantages and disadvantages of both No. 5 and 6. As both of the options had sedimentation problems, the students went online to search for relevant information about how this problem could be solved. They summarized their decision-making process before starting to make their poster. "Safety" and "the least harm to the natural environment" were the two most important criteria valued by group 4. Other criteria such as the number of people needing to be relocated, the impacts on cultural and historical relics, and the lifespan of the dam were also considered, but they were not prioritized or given weights. Location No. 5 was chosen because

Table 5. A summary of GP4's group discussion and decision making

Time	Transcript Numbering	Discussion Theme
0:01.00–0:04.06	1-11	Group members gave self-introduction.
0:04.06–0:16.03	16-30	Group members took turns expressing their criteria and considerations when deciding where to build a dam.
0:16.03–0:24.23	31-40	Group members took turns expressing their decision-making processes.
	Group Decision-Making	
0:24.23–0:26.59	46-53	Summarize group members' criteria and decision making ・Locations No. 1, 5, and 6 were selected because they had larger water storage capacity. ・Location No.1 was eliminated because it was very close to a fault line. ・One group member reflected: In fact, everybody has different priorities for their considerations.
0:26.59–0:28.45	54-56	Group members gave reasons for selecting location No.5. ・(Pros) Non-threatening to the natural environment. ・(Pros) Non-threatening to cultural and historical relics. ・(Pros) Not close to fault lines. ・(Pros) Relatively fewer people need to be relocated. ・(Pros) Larger catchment area. ・(Cons) Serious sedimentation problems. ・(Cons) Higher cost for dealing with the problems.
0:28.45–0:31.56	57-73	Group members gave reasons for selecting location No.6. ・(Pros) Lower maintenance fee. ・(Pros) Catchment area is OK. ・(Cons) Have some impacts on endangered species.
0:31.56–0:36.56	74-93	Group members went online to look for compensatory approaches to solve sedimentation problems.
0:36.56–0:40.24	93-110	Gave priorities to different criteria and made the final decision. ・Indicated that "safety" and "the least harm to nature" are the two most valued criteria. ・The number of people being moved, the impacts on cultural and historical relics, and life expectancy of the dam are also considered. Location No.5 met those criteria and the sedimentation problems can be solved by certain approaches, such as water and soil conservation.
0:40.39–0:54.40	110-250	Group members made a poster for presentation.

it seemed to meet most of the criteria, and the sedimentation problems can be solved using certain approaches.

Discussion and Implication

With the support of the web-based learning environment, the study engaged undergraduate students in socioscientific learning on the topic of water resources. The study investigated the similarities and differences in students' interdisciplinary thinking at the individual and collective levels, and explored to what extent these groups of students were able to make an informed collective decision. Our findings indicated that, compared to individual decision making, the students tended to show more moral or ethical considerations and make more links to previous learning or life experiences when engaged in group discussion. The students were able to perform thorough trade-offs during individual decision making. However, none of the groups adopted a compensatory strategy to make an informed group decision. This section discusses relevant issues pertaining to the findings.

Supporting interdisciplinary thinking in socioscientific decision making

Socioscientific issues normally present societal dilemmas with various connections to science or technology. As these issues exhibit strong connections to societal interest, impact, and consequences, they have inevitable associations with moral or ethical considerations (Sadler, Amirshokoohi, Kazempour, & Allspaw, 2006). Previous research has delved into students' decision making in some particular morally sensitive socioscientific issues such as cloning or genetic therapy. The research findings showed that moral concerns were significant factors influencing individual decision making. Fleming (1986a, 1986b) looked into adolescents' viewpoints on nuclear power and genetic engineering, and found that the majority of the students adopted moral reasoning during the socioscientific reasoning process. Bell and Lederman (2003) used an open-ended questionnaire and interviews to explore participants' views on four different socioscientific issues (fetal tissue implantation, global warming, the relationship between diet and cancer, and the relationship between cigarette smoking and cancer). Their results showed that 85% of these responses could be classified as moral or ethical concerns. Sadler and Zeidler (2004) explored to what extent undergraduate students perceived genetic engineering as a moral problem. The qualitative analysis also pointed out that moral concerns had significant effects on the students' decision making.

The socioscientific scenario adopted in the study: where to build a dam, also required moral considerations. When selecting a suitable location to build a dam, one might ponder, for example, how this would impact on the residents around the location and whether or not it is moral to ask these people to move from their hometown in order to benefit the whole society. Nevertheless, moral considerations did not seem to be major factors affecting the students' individual or collective decision making. In fact, the nature of the issues pertaining to water resources and genetic engineering is significantly different in nature. Therefore, students might employ some specific perspectives to reason and make their decisions depending on the nature of the socioscientific issues (Wu & Tsai, 2011). To improve moral reasoning in socioscientific decision making, relevant studies have suggested that, instead of giving direct instructions about how to negotiate the ethics involved in these controversial issues, educators should provide students with "a forum for exploring consequences, principles, emotions, and intuitions" (Sadler & Zeidler, 2004, p. 22). By means of such a forum, students will be empowered to tackle the complexity of the issue and to resolve the problems on their own. Future research may look into the instructional design of the forum and explore its practicability and effectiveness in terms of promoting moral reasoning in soicioscientific decision making.

It is argued that students' understanding of the nature of science and evaluation of evidence are crucial for making thoughtful socioscientific decisions (Khishfe, 2012; Kolstø, 2001; Tytler, 2001; Zeidler, Walker, Ackett, & Simmons, 2002). One's understandings of the nature of science would affect the way one interprets and makes use of the scientific data related to the socioscientific issue. In the study, however, arguments related to these two important dimensions appeared to be missing in both the students' individual and collective interdisciplinary thinking. Researchers have suggested that if one possessed more refined views on the role of experiments in science and their justifications of scientific knowledge, one may exhibit better reasoning skills (Wu & Tsai, 2011). Moreover, students who perceive scientific knowledge as changing and provisional in nature are more likely to appreciate the complexity of contexts, and to use multiple perspectives in the decision-making process (Liu et al., 2011). The lack of the use of certain dimensions in making arguments in fact highlights the importance of teaching or instructional prompts for advancing students' interdisciplinary thinking about socioscientific issues. It also echoes previous research findings that students need to be guided to integrate and apply their understandings of the nature of science when evaluating and making decisions on contentious socioscientific issues (Walker & Zeidler, 2002).

Improving collective socioscientific decision making with explicit instruction

Balgopal et al. (2017) expressed that students' out-of-school experiences played an important role in framing their arguments about socioscientific issues. As the group members were different individuals, they had attended different learning programs and had thus experienced different teaching traditions or training. These individual differences, on the one hand, helped expand divergent perspectives in the group discussions. On the other hand, they underlined the significance of discussion, negotiation, and compromise among group members in group decision making.

Previous researchers have recommended using a decision-making structure to guide and support discussions (Grace et al., 2015; Lee & Grace, 2012; Ratcliffe, 1997). They have also identified several critical features of high-quality discussion. In line with the research theme, this study explored students' decision making at the collective level. Our findings indicated that a few of the students were able to perform compensatory approaches individually, but none of the groups adopted these more sophisticated decision-making approaches to make collective decisions. Since the training part of the online unit introduced the three decision-making strategies, the students were likely to apply what they had just learned to the following task: individual decision making. In general, the groups were able to perform the decision-making phases. They were also able to consider the pros and cons of different options across a spectrum of disciplines and aspects. In agreement with previous studies, we found that the groups which explicitly expressed their awareness that different people actually made decisions based on their priority given to the criteria appeared to show more respect for different opinions and were inclined to use a more sophisticated approach to reach a group decision (Grace, 2009; Ratcliffe). Despite these quality features identified in the group discussions, we noted that deep reflections on group members' personal reasoning and more elaborated justifications were lacking in these group discussions. Besides, a useful decision-making strategy that can help systematically weight the pros and cons for all of the options was actually critical but absent in these group decision-making processes.

Merely grouping students will not automatically result in high-quality group work or meaningful discussions (Eggert et al., 2013). To strengthen students' collective decision-making competences, it is suggested that teachers may provide explicit instructions for scaffolding group discussions and group decision making. More specifically, the students will be guided to reflect on each other's reasoning and to select a useful decision-making approach to reach the final group decision.

Acknowledgements

This work was supported by the Ministry of Science and Technology, Taiwan, under Grant No. MOST 104-2511-S-003-054-MY3.

References

1. Acar, O., Turkmen, L., & Roychoudhury, A. (2010). Student difficulties in socio-scientific argumentation and decision-making research findings: Crossing the borders of two research lines. *International Journal of Science Education*, *32*(9), 1191-1206.
2. Aikenhead, G. S. (1985). Collective decision making in the social context of science. *Science Education*, *69*(4), 453-475.
3. Albe, V. (2008). When scientific knowledge, daily life experience, epistemological and social considerations intersect: Students' argumentation in group discussions on a socio-scientific issue. *Research in Science Education*, *38*(1), 67-90.
4. Balgopal, M. M., Wallace, A. M., & Dahlberg, S. (2017). Writing from different cultural contexts: How college students frame an environmental SSI through written arguments. *Journal of Research in Science Teaching*, *54*(2), 195-218.
5. Bell, R. L., & Lederman, N. G. (2003). Understandings of the nature of science and decision making on science and technology based issues. *Science Education*, *87*(3), 352-377.
6. Böttcher, F., & Meisert, A. (2013). Effects of direct and indirect instruction on fostering decision-making competence in socioscientific issues. *Research in Science Education*, *43*(2), 479-506.

7. Chang Rundgren, S.-N., & Rundgren, C.-J. (2010). SEE-SEP: From a separate to a holistic view of socioscientific issues. *Asia-Pacific Forum on Science Learning and Teaching*, *11*(1), Article 2.

8. Christenson, N., Chang Rundgren, S.-N., & Zeidler, D. L. (2014). The relationship of discipline background to upper secondary students' argumentation on socioscientific issues. *Research in Science Education*, *44*(4), 581-601.

9. Christenson, N., Chang Rundgren, S.-N., & Höglund, H.-O. (2012). Using the SEE-SEP model to analyze upper secondary students' use of supporting reasons in arguing socioscientific issues. *Journal of Science Education and Technology*, *21*(3), 342-352.

10. Eggert, S., & Bögeholz, S. (2010). Students' use of decision-making strategies with regard to socioscientific issues: An application of the Rasch partial credit model. *Science Education*, *94*(2), 230-258.

11. Eggert, S., Ostermeyer, F., Hasselhorn, M., & Bögeholz, S. (2013). Socioscientific decision making in the science classroom: The effect of embedded metacognitive instructions on students' learning outcomes. *Education Research International*, *2013*. doi: 10.1155/2013/309894

12. Evagorou, M., & Osborne, J. (2013). Exploring young students' collaborative argumentation within a socioscientific issue. *Journal of Research in Science Teaching*, *50*(2), 209-237.

13. Fleming, R. (1986a). Adolescent reasoning in socio-scientific issues, part I: Social cognition. *Journal of Research in Science Teaching*, *23*(8), 677-687.

14. Fleming, R. (1986b). Adolescent reasoning in socio-scientific issues part II: Nonsocial cognition. *Journal of Research in Science Teaching*, *23*(8), 689-698.

15. Grace, M. (2009). Developing high quality decision-making discussions about biological conservation in a normal classroom setting. *International Journal of Science Education*, *31*(4), 551-570.

16. Grace, M., Lee, Y. C., Asshoff, R., & Wallin, A. (2015). Student decision-making about a globally familiar socioscientific issue: The value of sharing and comparing views with international counterparts. *International Journal of Science Education*, *37*(11), 1855-1874.

17. Gresch, H., & Bögeholz, S. (2013). Identifying non-sustainable courses of action: A prerequisite for decision-making in education for sustainable development. *Research in Science Education*, *43*(2), 733-754.

18. Gresch, H., Hasselhorn, M., & Bögeholz, S. (2013). Training in decision-making strategies: An approach to enhance students' competence to deal with socio-scientific issues. *International Journal of Science Education*, *35*(15), 2587-2607.

19. Gresch, H., Hasselhorn, M., & Bögeholz, S. (2017). Enhancing decision-making in STSE education by inducing reflection and self-regulated learning. *Research in Science Education*, *47*(1), 95-118.

20. Hsu, Y.-S., & Lin, S.-S. (2017). Prompting students to make socioscientific decisions: Embedding metacognitive guidance in an e-learning environment. *International Journal of Science Education*, *39*(7), 964-979.

21. Jho, H., Yoon, H.-G., & Kim, M. (2014). The relationship of science knowledge, attitude and decision making on socio-scientific issues: The case study of students' debates on a nuclear power plant in Korea. *Science & Education*, *23*(5), 1131-1151.

22. Jiménez-Aleixandre, M. P. (2002). Knowledge producers or knowledge consumers? Argumentation and decision making about environmental management. *International Journal of Science Education*, *24*(11), 1171-1190.

23. Khishfe, R. (2012). Nature of science and decision-making. *International Journal of Science Education*, *34*(1), 67-100.

24. Kolstø, S. D. (2001). "To trust or not to trust, ..."—pupils' ways of judging information encountered in a socio-scientific issue. *International Journal of Science Education*, *23*(9), 877-901.

25. Kolstø, S. D. (2006). Patterns in students' argumentation confronted with a risk-focused socio-scientific issue. *International Journal of Science Education*, *28*(14), 1689-1716.

26. Kortland, K. (1996). An STS case study about students' decision making on the waste issue. *Science Education*, *80*(6), 673-689.

27. Lee, Y. C., & Grace, M. (2012). Students' reasoning and decision making about a socioscientific issue: A cross-context comparison. *Science Education*, *96*(5), 787-807.

28. Levinson, R. (2008). Promoting the role of the personal narrative in teaching controversial socio-scientific issues. *Science & Education*, *17*(8-9), 855-871.

29. Linn, M. C., & Eylon, B.-S. (2011). *Science learning and instruction: Taking advantage of technology to promote knowledge integration*. New York: Routledge.

30. Liu, S.-Y., Lin, C.-S., & Tsai, C.-C. (2011). College students' scientific epistemological views and thinking patterns in socioscientific decision making. *Science Education*, *95*(3), 497-517.

31. Nielsen, J. A. (2012). Science in discussions: an analysis of the use of science content in socioscientific discussions. *Science Education*, *96*(3), 428-456.

32. Papadouris, N. (2012). Optimization as a reasoning strategy for dealing with socioscientific decision-making situations. *Science Education*, *96*(4), 600-630.

33. Papadouris, N., & Constantinou, C. P. (2010). Approaches employed by sixth-graders to compare rival solutions in socio-scientific decision-making tasks. *Learning and Instruction*, *20*(3), 225-238.

34. Ratcliffe, M. (1997). Pupil decision-making about socio-scientific issues within the science curriculum. *International Journal of Science Education*, *19*(2), 167-182.

35. Sadler, T. D. (2004). Informal reasoning regarding socioscientific issues: A critical review of research. *Journal of Research in Science Teaching*, *41*(5), 513-536.

36. Sadler, T. D., Amirshokoohi, A., Kazempour, M., & Allspaw, K. M. (2006). Socioscience and ethics in science classrooms: Teacher perspectives and strategies. *Journal of Research in Science Teaching*, *43*(4), 353-376.

37. Sadler, T. D., & Zeidler, D. L. (2004). The morality of socioscientific issues: construal and resolution of genetic engineering dilemmas. *Science Education*, *88*(1), 4-27.

38. Sadler, T. D., & Zeidler, D. L. (2005). Patterns of informal reasoning in the context of socioscientific decision making. *Journal of Research in Science Teaching*, *42*(1), 112-138.

39. Siegel, M. A. (2006). High school students' decision making about sustainability. *Environmental Education Research*, *12*(2), 201-215.

40. Svenson, O. (1992). Differentiation and consolidation theory of human decision making: A frame of reference for the study of pre- and post-decision processes. *Acta Psychologica*, *80*(1), 143-168.

41. Tytler, R. (2001). Dimensions of evidence, the public understanding of science and science education. *International Journal of Science Education*, *23*(8), 815-832.

42. Walker, K. A., & Zeidler, D. L. (2002). *Students' understanding of the nature of science and their reasoning on socioscientific issues: A web-based learning inquiry*. Paper presented at the 2002 NARST Annual Meeting of National Association for Research in Science Teaching. Philadelphia, PA.

43. Wu, Y.-T., & Tsai, C.-C. (2007). High school students' informal reasoning on a socio-scientific issue: Qualitative and quantitative analyses. *International Journal of Science Education*, *29*(9), 1163-1187.

44. Wu, Y.-T., & Tsai, C.-C. (2011). High school students' informal reasoning regarding a socio-scientific issue, with relation to scientific epistemological beliefs and cognitive structures. *International Journal of Science Education*, *33*(3), 371-400.

45. Yang, F.-Y., & Anderson, O. R. (2003). Senior high school students' preference and reasoning modes about nuclear energy use. *International Journal of Science Education*, *25*(2), 221-244.

46. Zeidler, D. L., Sadler, T. D., Simmons, M. L., & Howes, E. V. (2005). Beyond STS: A research-based framework for socioscientific issues education. *Science Education*, *89*(3), 357-377.

47. Zeidler, D. L., Walker, K. A., Ackett, W. A., & Simmons, M. L. (2002). Tangled up in views: Beliefs in the nature of science and responses to socioscientific dilemmas. *Science Education*, *86*(3), 343-367.

48. Zohar, A., & Nemet, F. (2002). Fostering students' knowledge and argumentation skills through dilemmas in human genetics. *Journal of Research in Science Teaching*, *39*(1), 35-62.

科學教育學刊
2017, 第二十五卷第四期, 391-412
DOI: 10.6173/CJSE.2017.2504.04

Chinese Journal of Science Education
2017, 25(4), 391-412

探討大學生在社會性科學議題情境中個人與集體決策能力之展現

方素琦　許瑛玿*
國立臺灣師範大學　科學教育研究所

摘要

本研究根據決策框架發展以水資源為主題的線上教學模組以培養大學生社會性科學議題個人和集體決策能力。本研旨在探究並比較大學生在社會性科學議題中「個人」與「小組」層次之間多面向思考以及應用決策策略的異同。學生個別完成水資源線上教學模組，根據教學情境中提供的資料進行思考判斷，並決定一個合適的地點建水庫。課堂中學生先分組進行討論，最後需達成共識完成一個集體的決策。本研究中社會性科學議題多面向思考依據SEE-SEP架構進行質性分析，決策能力則依文獻分成不同精熟程度。研究發現，學生在小組討論中較常使用道德方面的論述並連結個人的經驗於論點中。部分學生進行個別決策時可展現較高層次的決策能力。然而，小組集體決策時缺乏系統性優缺點比較，也未使用較高層次的決策方法。本研究結果所指出小組決策過程中的不足恰反應了教學引導在提升小組決策能力的重要性。建議未來社會性科學議題教學可提供小組進行討論和集體決策的結構性教學框架，以提升學生集體決策能力與決策品質。

關鍵詞：決策能力、社會性科學議題、線上學習環境

*通訊作者：許瑛玿，yshsu@ntnu.edu.tw