Liu, C.-C. et al. (Eds.) (2014). Proceedings of the 22nd International Conference on Computers in Education. Japan: Asia-Pacific Society for Computers in Education

# Equipping High School Students with the Abilities of Evaluating Evidence and Formulating Evidence for an On-line Decision-making Task

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**Abstract:** Preparing students with appropriate abilities for taking some of on-line tasks is necessary. It will help students to build self-confidence and increase the probability to reach the success of learning. The purpose of this study aimed at equipping high school students with the skills of evaluating evidence and formulating evidence for taking an on-line task, in which students had to make a decision on choosing a location to build a reservoir. The developed instructional activity was a 4-hour unit, which provided a socioscientific context for students to understand the concept about evidence and discuss the reliability and validity of evidence to support if the global warming has been accelerating. The participant consisted of one earth science teacher and forty students. Two questionnaires and individual interviews were used to collect data. The results showed that the students had significant improvement in evaluating evidence, formulating evidence and justifying their arguments. Their understandings of criteria used for evaluating evidence became more clearly after the teaching. Most students reported that the instruction was beneficial for them to complete the decision-making task.

**Keywords**: Making decision, evidence evaluation, evidence formulation

## 1. Introduction

If a decision maker wants to make an evidence-based decision, he/she have to find evidence, evaluate evidence, use evidence, and justify his or her decision with evidence. These abilities are important but have been paid little attention in science curriculum and instruction. Therefore, Gott and Duggan (2007) advocated that science education has to get procedural and declarative understanding of evidence involved in science instruction. Prior studies have revealed that many of the students, from elementary students to university students, have difficulties in using evidence to support their arguments (Sandoval, Sodian, Koerber, & Wong, 2014), coordinating the claim or conclusion with the evidence (Zimmerman, 2007), and evaluating evidence (Nicolaidou, 2011). These abilities regarded as higher cognitive thinking skills are vital for students to deal with some issues, especially they are asked to make a decision in a socioscientific context. The socioscientific issue is one kind of scientific and social issues, which embed with some problems, controversies and dilemma caused by the application and development of science and technology (Zeidler et al, 2005), such as genetically modified organisms, radiation of mobile phones, or building a reservoir etc. People argue the solutions of the problem in an issue without reaching a conclusion. Zeidler and Nichols (2009) suggested that science teachers can select an appropriate socioscientific issue (SSI) for instruction, lead students to examine and discuss the arguments the stakeholders have, evaluate evidence of each argument with criteria, practice making a decision and justifying their decision with evidence. It means before making a decision on a SSI, there are many steps regarding understanding of and using of evidence involved in the process that are difficult for most of students. Hug and McNeil (2008), Schalk, Van der Schee and Boersma (2013) suggested that it is helpful for students to make a deliberate decision after they experience the instruction planned to improve their understanding of

evidence and skills of evaluating and using evidence. In this study, we attempt to equip high school students with the skills of evaluating evidence and formulating evidence before they take an on-line decision-making task.

## 2. Method

### *2.1 Participants*

The participants consisted of one experienced teacher and forty grade eleven students (27 girls and 13 boys). The earth science teacher has 20-year teaching experiences. She joined the workshop held by the researcher to learn the declarative and procedural knowledge about evidence, the operation and the contents of software, and to discuss the teaching materials and methods with the researcher. The students whose age was 16-17 years old did not have the formal experiences to evaluate evidence, formulate evidence and justify arguments with evidence before.

### *2.2 The Instruction*

The instruction was to enhance the students' understanding of the concept of evidence, and improve their abilities to evaluate evidence, formulate evidence and justify arguments with evidence. The instructional unit included four hours. At the first two hours, the teacher led the students to discuss the importance of evaluating and using evidence in everyday life. After the criteria used to evaluate the reliability and validity of evidence were developed through group discussion, the students assessed the criteria each group formulated for their appropriateness through the whole class discussion. During the last two hour, one text provided for the students to read includes five stakeholders and their arguments to the question – "Global warming becomes more serious than before. Is it man-made? Each argument had at least one piece of evidence to support that it is caused by man-made. The students were led to discuss the reliability of evidence, the relevance between the evidence and the claim, and how to make much stronger evidence to support or rebut the claim and justify their arguments.

### *2.3 The software and the task*

The students were asked in a software environment to complete an evidence-based decision-making task, in which they had to choose an appropriate location to build a reservoir within a limited time. During the trial-and-error process of making decision, they had to use the abilities of formulating criteria, selecting and evaluating evidence, and justify their choice with evidence. Figure 1 shows one of the interfaces of "Constructing Reservoir" software.


*Fig.1 The interface of "Constructing Reservoir" software*

### *2.4 Instruments*

The questionnaire "Evidence evaluation and use" included a scientific research context and three

questions. The context described three animal studies on exploring the function of onions, the results and the consistent conclusions. Three questions were used to assess the students' abilities to generate an argument, evaluate the reliability of the evidence, and formulate evidence to support the arguments. The questions are: (1) Do you agree or disagree with the conclusion of three animal studies? Why? (2) Do you think the evidence the author described is reliable to support the conclusion? Explain why in detail. (3) If the scientists can make more evidence to support the conclusion, do you think what it is? Explain your reasons. The pre- and posttest administered to the students before and after the instructional intervention were the same. The other questionnaire is "Reflection on Learning" used to collect the students' feedback about the instruction. It was related to their attitude towards the teaching contents, methods and their reflection on learning for completing the decision-making task.

## 3. The Results

A series of t-test were run to examine the improvement of the students' abilities after instructional intervention (Table 1). The findings showed that the students had statistically significant improvement in scores for making warrants, evaluating the reliability of the evidence, and formulating evidence to support the arguments ($p$<.01).

*Table 1 Summary of the paired t-test for the scores of making warrants, evidence evaluation and formulation*

| Questions | Mean(S.D.) | | *t* value |
|---|---|---|---|
| | Pretest N=40 | Posttest N=40 | |
| Making warrants | 1.40(0.81) | 2.15(1.19) | 4.39(0.00**) |
| Evaluating evidence | 1.35(0.92) | 2.13(0.97) | 5.69(0.00**) |
| Formulating evidence | 1.43(0.68) | 2.17(0.96) | 4.13(0.00**) |
| Total Scores | 4.18(1.89) | 6.45(2.09) | 12.23(0.00**) |

Figure 2 and 3 respectively revealed that the criteria the students used for evaluating evidence were a few different before and after the instruction. The criteria of "time" used in the posttest instead of in the pretest. The criteria the students used for formulating evidence were the same in the pretest and posttest. The number of criteria appeared in posttest had been significantly increased than in the pretest in both abilities.

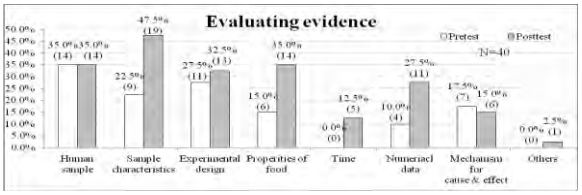


Fig2. The criteria the students used for evaluating evidence in pretest and posttest

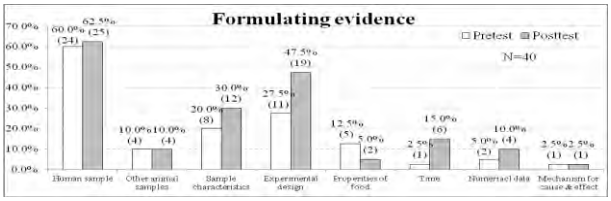


Fig3. The criteria the students used for formulating evidence in pretest and posttest

Meanwhile, according to the feedbacks the students expressed in the questionnaire, most of the students pointed that they benefited a lot from the instruction. For example, the student S03 said that "if without the instruction before I took the decision-making task, I nearly did not have the idea to use criteria to evaluate and select evidence to help myself to complete it."

## 4. Conclusions

The instructional design in this study supports the students to develop the abilities in making arguments, evaluating evidence and formulating evidence to support their arguments. Based on the students' feedback and individual interviews, it is really helpful for the students to apply these abilities to take the decision-making task in the software environment.

However, it is not enough to proof that all of the students transfer these abilities well for taking the task in this pilot study. Therefore, the researcher further plans to adopt " two-group pretest-posttest experimental design". The experimental group receives the instruction this study showed. The control group receives the instruction without emphasizing on learning to develop criteria for evidence evaluation. Through the comparison we can confirm the effect of instructional intervention. Moreover, the researchers will examine what strategies the students adopt during the period of taking the task. It will reveal the abilities the students apply in the task.

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