Teaching argumentation through the visual models in a resource-based learning environment

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Abstract

Scientific literacy is the ultimate goal in science education world-wide; especially in this modern society of science and technology. How to help individuals to make good judgments and promote their skills of argumentation becomes an important issue. Meanwhile, in the Information Age, visual image is an important medium for conveying information. The purpose of this study is to teach argumentation through visual models in a non-science major class and to investigate which visual models of argumentation students like to choose for constructing their arguments concerning genetically modified food

in a resource-based learning environment. The results revealed that most of the participants chose Lakatos' scientific research programmes as the model to construct their arguments most, and there were three kinds of reasons participants provided about why they chose this model. In addition, the questions concerning genetically modified food that students felt interested to explore were also investigated. The implications for teaching are discussed.

Keywords: argumentation, visual model, socioscientific issues, resource-based learning

Introduction

To enable individuals to live well in the current modern society of science and technology, cultivating and raising students' scientific literacy in the different disciplines has become the goal of science education worldwide (AAAS, 1993; MOE, 1998). In terms of teaching to promote scientific literacy, continuous changes in education have had to be made in many countries (Bell, Abd-El-Khalick, Lederman, McComas, & Matthews, 2001; McComas, Almazroa, & Clough, 1998), Taiwan is no exception. Besides the emphasis upon teaching the concepts of science and technology, in Taiwan's last curriculum reform, habits of mind is one of the curriculum indicators applied in grades 1-9, which aims to enable students to have the ability to integrate information, make judgments and infer from socioscientific issues, solve problems, and so forth (Chang & Chiu, 2005a; MOE, 1998). Besides the importance of promoting scientific literacy, learning from resource-based environment has become a big issue. In the drift of using the Internet, more and more information is stored and presented electronically all over the world nowadays, therefore the most popular resource people use for searching information is the Internet. There has been an emphasis on students' learning to be self-regulated from the interaction with a wide range of learning resources (Neumann, Gräber, & Tergan, 2005; Rakes, 1996). According to the emphases upon scientific literacy and resource-based learning, the skills of argumentation are essential for modern citizens and professionals, especially living in the Information Age. How to make people argue well from the various information they could obtain in this Information Age turns into the issue educators need to concern about and work with. In this study, it was considered the use of visual model could benefit teachers' teaching and students'

learning about argumentation. In the following section, the idea of resource-based learning and the importance of using visual models in education are described. Meanwhile, three existing visual models of argumentation, which are adopted in this study, are delineated as well.

Resource-based learning and the Internet

Resource-based learning has become important in this Information Age. Briefly, resource-based learning implicates examining a topic and locating the information to answer questions or to solve problems related to this topic (Rakes, 1996). Rakes (1996) mentioned information resources could embrace print and non-print media, ranging from books/articles to sound/video recordings, and to electronic databases or other computer-based resources. Nowadays the Internet is the prevalent medium of the information resources. The Internet provides the possibility of reinforcing instruction and learning in a resource-based learning environment. Some of the advantages of using Internet have been mentioned that it offers the opportunity to benefits engage students as active participants and helps some people participate more easily, learn more effectively, and enjoy their learning more. Besides the benefits to learners, the Internet can also provide both teachers and students with an ever-growing source of information (Hargis, 2001).

Moreover, resource-based learning can be illustrated as a learning model in which students learn from their own interaction with a wide range of information resources rather than from conventional class exposition (Brevik & Senn, 1994; Rakes, 1996). Regarding the resource-based learning model, it emphasizes on six points as below:

- Teacher as the facilitator/guide
- Variety of sources/media
- Questions as primary
- Information is discovered
- Emphasis upon process
- Assessment is quantitative/qualitative

Rakes pointed out the idea that resource-based learning is strongly related to the Inquiry Training model of instruction, and students learn better when presented with a problem or question of genuine interest (Rakes, 1996). Therefore, in this study the

resource-based learning model was embedded in the instructional design for teaching argumentation. Namely, a resource-based learning environment was provided for students to utilise and develop their argumentation about genetically modified food in this study.

The importance of visual image in education

Before presenting the visual models of argumentation, it is essential to point out the importance of the use of visual imagery for learning. Visualization is deemed a helpful medium for understanding and remembering information. From the perspective of cognitive psychology, it is well known that graphical thinking is one of the strategies for enhancing an individual's memory, due to visual images making the abstract more concrete and enabling learners to explain complex information simply (Rakes, 1999). It has also been suggested that using visual-spatial strategies may reduce cognitive load and help learners in managing their ideas and making connections between the information resources (Neumann, Gräber, & Tergan, 2005). Besides visual image, theory also needs to be emphasized and concerned while developing instruction. Some researchers mentioned that models can provide the visual perception of physical structure and relationship, and theory can delineate and interpret the meaning of the structure (Glynn, Yeany, & Britton, 1991; Keys, 1997). Therefore, in this study, the visual model of argumentation is considered to be good approach in teaching argumentation.

The existing visual models of argumentation

More and more researchers think science education ought to equally emphasize cognitive psychology and philosophy of science for the sake of developing better instruction in science education (Duschl & Hamilton, 1992; Nersessian, 1989; Perkins, 1985; Perkins & Salomon, 1989; Resnick, 1987). Therefore, I tried to adopt theoretical models regarding argumentation from the domains of psychology and philosophy for the instructional design. Three visual models of argumentation were considered for assisting students' argumentation, which are Toulmin's model (Toulmin, 1958), Means and Voss's model (Means & Voss, 1996), and Lakatos' scientific research programmes (Chang & Chiu, 2005b).

Toulmin's model (Toulmin, 1958) has been applied by many researchers for analyzing argumentation (Erduran, Simon, & Osborne, 2004; Fimenez-Aleixandre, 2002; Kelly & Chen, 1999; Russell, 1983; Simonneaux, 2001; Tirri & Pehkonen, 2002). Since the early periods, some philosophers like Plato, Socrates and Aristotle concerned themselves with thinking, and all of them thought that reasoned arguments constructed the core of thinking (Kuhn, 1991). From that time, formal logic was taken as the best model of thinking until the middle of the twenty century. In 1958, Toulmin published the important book entitled "*The uses of argument*", where he pointed out the limits of using formal logic to think and brought up his own model of a reasoned argument and emphasized the advantages of using argumentation as a kind of thinking (Toulmin, 1958). Composing Toulmin's model are data, claim, backing, warrant, qualifier and rebuttals (Figure 1), where special features of the elements need to be pointed out, e.g. warrant is looked upon as a hypothetical and bridge-like statement, backing is regarded as the categorical statements of fact, and qualifier is taken as a tentatively qualified conclusion (Toulmin, 1958). The example is also presented in Figure 1.

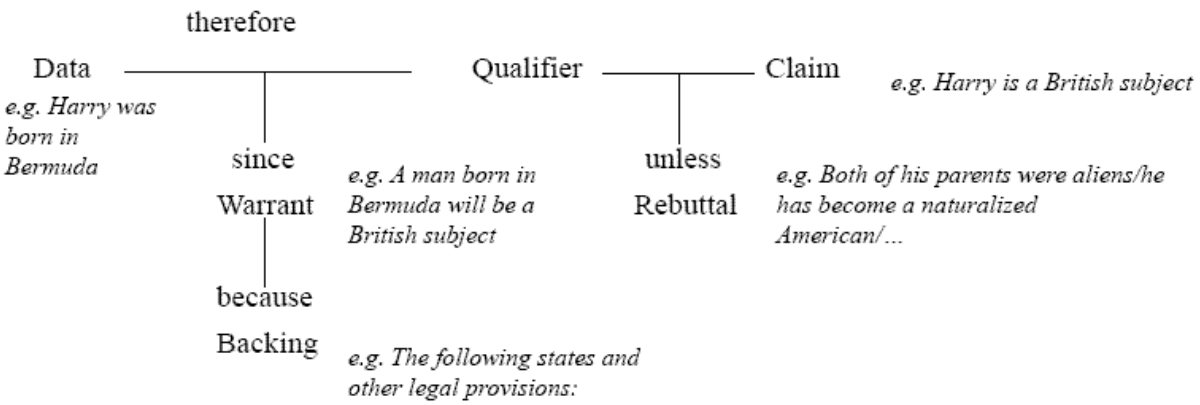

Figure 1: *Toulmin's model of argumentation (Toulmin, 1958)*

In 1996, Means and Voss provided three models generated from an empirical study regarding informal reasoning process (Means & Voss, 1996), but these models could be traced back to 1991. Based upon the Aristotle's enthymeme, Voss and Means brought up their first model of argumentation (Figure 2), in which there is a supporting reason and a claim (Figure 2A), and also pointed out the existence of contradiction to the claim (Figure 2B) (Voss & Means, 1991). Moreover, they

generated three advanced models from their empirical study regarding informal reasoning (Figure 3), which include the skeletal model, the enhanced model, and the elaborated model (Means & Voss, 1996). In the skeletal model, people only generate a reason (R) to support the conclusion (C) (Figure 3A), and the enhanced model is with qualifiers (Q) which provides various solutions of various conditions (Figure 3B). In terms of the elaborated model, it includes more reasons and qualifiers, and the presence of the counterargument (using "=" to show the contradiction status) (Figure 3C).

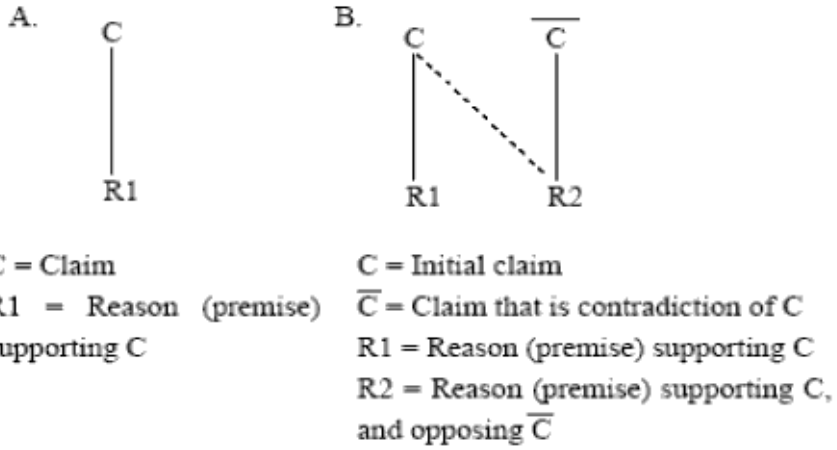

Figure 2: *Voss and Means's model of argumentation (Voss & Means, 1991)*

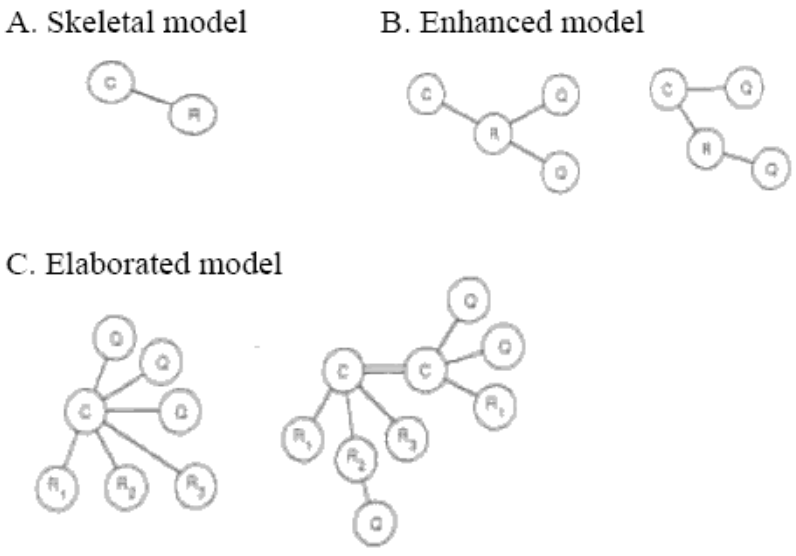

Figure 3: *Means and Voss's three advanced models (Means & Voss, 1996)*

Due to some limitation found while analyzing students' informal argumentation regarding socioscientific issues, Lakatos' scientific research programmes, a famous theory in the field of philosophy of science, was presented as an alternative theoretical model for analyzing argumentation (Chang & Chiu, 2005b). Lakatos's programmes embraces the five indicators regarding the skills of informal argumentation, which include (Chang & Chiu, 2005b):
Making claims: individuals could make the claims for issues.

- Providing supporting reasons: individuals could provide reasons or information to support their conclusions.
- Presenting counterarguments: individuals could sense the opposite argument or the limitation of the argument.
- Showing qualifiers: individuals could provide alternative solutions for expanding their conclusions.
- Evaluating arguments: individuals could evaluate their own or other people's arguments.

The main essence of the Lakatos' programmes stresses the concept of *a series of theories* instead of the concept of *theory*, the basic concept from logic of discovery (Lakatos, 1978). There are four connected components embedded in the Lakatos' model which are hard-core (HC) located in the core of the model, protective belt (PB) surrounding HC, negative heuristic (NH) and positive heuristic (PH) holding in the model (Lakatos, 1970). HC is the core and foundation of the theory and it possesses the tough and unchangeable features. PB is composed by auxiliary hypotheses for preventing HC from being attacked. NH and PH are both strategies embedded in the model with separate functions to forbid rebuttals and to expand theory. Moreover, there is an important function of PB is to adjust the auxiliary hypotheses when the theory meets the anomaly and could absorb the anomaly via NH and PH. The graphical representation of the Lakatos' scientific research programmes is shown in Figure 4. The basic idea is to use the middle circle symbolizing HC, and PB is another bigger circle surrounding HC. Furthermore, two arrows used to show NH and PH in PB. The same direction with the running minute hand represents PH, and reversed one stands for NH.

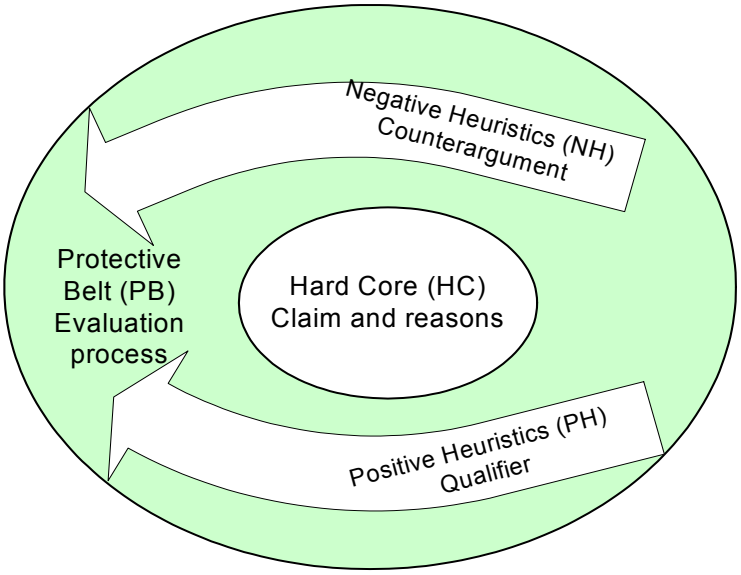

Figure 4: *Lakatos's scientific research programmes model*

The example of using Lakatos' programmes to construct arguments regarding genetically modified food has been implemented and found it is a workable model by Chang and Chiu (2005b). The quotation from the past study is as below.

> *(HC) I would buy the genetically modified food (claim), because I learned about genes from a biology course, which makes me know our genes will not change after we eat the genetically modified food (reason). Besides, genetically modified food has its exploitable value, if our government did not make an effort, then our country will fall behind other countries (PH). Generally, we have not heard anything harmful to humans, but it is necessary to conduct clinical trials like the process before marketing the medicine (NH).*

In accordance with the theoretical background, the purpose of this study is to teach argumentation through the presentation of visual models in a resource-based learning environment. The research questions include: (1) what kind of visual model do most participants choose to construct their arguments? (2) what are the reasons for choosing this visual model? (3) what kind of questions do participants feel interesting to explore concerning genetically modified food (GMF)?

Method

A total of 38 non-science majors participated in this study, and the participants were all part-time students who work on weekdays and study for Bachelor degree on weekends. The 38 participants all work in the fields of business and management. They joined an eight-weekend logic course (four hours per weekend) from September 2005 to January 2006. The course content was divided into two main parts. In the first part, *formal logic/symbolic reasoning* was taught for four weekends, and *everyday reasoning* was for another four weekends. The whole instruction and activity conducted in this study was allocated to the *everyday reasoning* part, and it took two weekends (a total of 8 hours) for the introduction of the concepts regarding everyday reasoning and visual models of argumentation. Participants' skills of orally presentation were noticed as well.

The steps for implementing this study included the introduction of the concepts regarding everyday reasoning and the previously mentioned three visual models of argumentation. Using the resource-based learning model, participants were asked to search information concerning the GMF issue after class, and choose one of the argumentation models to construct their arguments. Participants needed to provide the reason(s) why they chose this model to construct their arguments and what question(s) they felt interested to explore in a resource-based learning environment concerning GMF. Participants were all requested to present their own ideas and models orally in the class, and could let audiences ask questions during presentation. There was a student guide sheet provided for participants to prepare their presentations and the written reports that were due on the next weekend. The data were analyzed from participants' written reports and researcher's field notes. The guide sheet had seven questions as shown below:

Topic: Will you eat genetically modified food (GMF)?

Q1. Before searching the information regarding GMF, please write down the concept you currently know about GMF.

Q2. What kinds of questions you would like to investigate about GMF?

Q3. Following with Q2, what kinds of resource will you search for answering the questions by you?

Q4. What kind of visual model regarding argumentation would you like to choose for constructing your argument regarding eating GMF or not?

Q5. Following with Q4, why did you not choose the other two models?

Q6. Please present the model of your arguments!

Q7. According to the process while you constructed your argument, have you found any limitation of this model? And have you found any expansion of this model?

Results

The results show that 36 of the 38 participants chose Lakatos' scientific research programmes to construct their arguments. There were three categories of reasons regarding why students chose Lakatos' programmes described as follows.

Comments on the structure of the model itself

Twenty seven participants mentioned that the reason they choose Lakatos' programmes was because of the structure of model itself. Among the 27 participants, 26 of them mentioned that Lakatos' programme is a simple model and could be used easily for beginners (Mr. MHC's answer is quoted). One participant pointed out the positive heuristic and negative heuristic was useful (Miss WYJ's answer is quoted).

Mr. MHC: *The reason for choosing this model is because the graph looks simple and the model is easy to understand. Also this model is suitable for beginners to handle.*

Miss WYJ: *The main reason to choose Lakatos' model is because it is easy to understand and suitable for a beginner like me. By the way, it is a good way to construct arguments with positive (represent to positive heuristic) and negative (represent to negative heuristic) perspectives like Lakatos' model.*

Comments on participants' thinking processes

Ten participants thought that Lakatos' scientific research programmes was a model that fitted with their thinking processes (Miss CJL's answer is quoted).

Miss CJL: *The Laktos' model is just like my way to think. I think this model could construct my ideas very well, so I choose this model to present my argument.*

Comments on the theory of the model itself

Only one participant mentioned that the theoretical feature of Lakatos' model is the reason for choosing it for constructing arguments (Miss CHW's answer is quoted).

Miss CHW: *Lakatos' scientific research programmes is a more completed model to look at the progress about a series of theories. I think argument is firm to every individual when generated at the beginning, and it also takes time to be changed to another argument. The process of change is just like Lakatos' model.*

Furthermore, the questions participants felt interested in investigating in a resource-based environment concerning GMF could be grouped into seven categories. The categories and the number of participants presented in each category are given below. Due to participants often gave more than one question to investigate; the total number of questions is over 38, the number of participants.

1. The safety issue (21 participants): most participants wanted to know whether there is any side effect after eating GMF for our bodies.

2. The benefit after creating GMF (16 participants): many participants wanted to know whether GMF could produce food with more nutrients and then people do not need to take extra vitamins in the future; some mentioned perhaps GFM could be produced to cure diseases.

3. What kinds of GMF have been sold in the market so far and how would we recognize them (14 participants): many people would like to know whether they have eaten any GMF without noticing, and was there any label indicating GMF so that people could recognize it.

4. The impact on ecology (13 participants): some participants hoped to know whether the kind of GMF with insect-killing gene will kill humans as well, or damage the stability of the current ecology.

5. How to monitor the prevalence of GMF by government (4 participants): only a few people wanted to know how the government monitors GFM research and manages the GMF on the market.

6. The vegetarians' perspective on the recombination of animal gene in the vegetable (3 participants): vegetarian's viewpoint about eating the animal gene from GMF was also felt interested in investigating by three participants.

7. The cost of producing GMF (2 participants): Only two participants cared about how much money it costs to produce GMF.

When participants mentioned the limitations of using Lakatos' programmes to construct arguments, some participants who disagreed to buy GMF mentioned there was a difficulty in constructing positive and negative heuristics while dealing with GMF topic. They mentioned they could search and categorize the information regarding pros and cons easily, but it was hard to construct them as positive and negative heuristics of Lakatos' programmes.

Conclusion and the implication for teaching

In the current Information Age, resource-based learning is ubiquitous, and the Internet is the prevalent medium to search information. Accordingly, the need to develop argumentation has become increasingly important.

Visual models have been taken as an important method to simplify concepts and allow individuals to remember more easily. In this study, Lakatos' visual model was the one chosen most often by non-science participants for constructing their arguments about GMF. The reasons included that the representation and meanings of the components of this model are easy to understand, especially for beginners; participants' thinking process matched Lakatos' model. In addition, the theoretical description of Lakatos' programmes was acceptable by one of the participants. However, concerning the reasons why participants did not choose another two model to construct their

arguments, besides the complication of visual representation, participants also mentioned Toulmin's framework is too fragmental and was difficult to fit the information into each component; from the visual representation, the elements of Means and Voss's model are all in one-way direction, and participants thought thinking process should not be just one-way direction. Moreover, in terms of the questions participants chose to explore regarding GMF, most participants were concerned about the safety issues after eating GMF, the benefits people can get from GMF, how GMF are recognized in the market and the impact on ecology after creating GMF.

As a result of this study, it seems that Lakatos' model could be suitable for beginners (non-science students) to learn how to argue regarding socioscientific issues. This conclusion confirms the notion that Lakatos' model could be an alternative model when deal with socioscientific issues, except Toulmin's framework and Means and Voss's model (Chang & Chiu, 2005b). Teachers could provide the visual model of Lakatos' model first and then let students develop their arguments by using the model, especially during discussions about socioscientific issues. The categories of questions concerning GMF found from this study could be used as ideas for teachers to develop instruction in the future, since students seem to be interested and motivated by these perspectives. Questions are a fundamental aspect of resource-based learning models (Rakes, 1996). The limitations of Lakatos' model revealed in this study, indicate the need for teachers to demonstrate the process of argumentation first, and then let students argue accordingly. Otherwise, students would feel less able to construct the parts of positive and negative heuristics of Lakatos' model. In terms of the representation of visual models, teachers ought to make it simple and take care of the meaning to each symbol and the direction of arrows.

In summary, resource-based learning could provide students with the opportunity to explore and practice their argumentation skills, and the presentation of a visual model benefits student more when learning argumentation as well.

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