Ninth-Grade Students' Collaborative Modelling of Biomagnification Through MySystem

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Abstract: The study explored ninth-grade students' collaborative modelling of biomagnification through a modelling software named MySystem. Participants included forty-two students at a public junior high school in southern Taiwan. Data were collected through the group conversations during the modelling processes and system models of biomagnification the students collaboratively constructed. We used qualitative methods to analyze the data. The results revealed four types of students' collaborative modelling strategies (questioning, confirming, doubting and correcting) that mediated three facets of learning (meta-monitoring, concept clarification, and visualization) while the students were collaboratively constructing computer models. Furthermore, we reflected on future curriculum improvements to facilitate students' collaborative learning through a computer modelling tool.

Keywords: biomagnification, collaborative modelling, modelling technology

Introduction

Science models and modelling are important components of science practice. Models are products of science activities, while modelling is the process of exploration to create science models. Understanding students' collaborative modelling processes supported by computer tools can provide evidence of the benefits of technology and reflections on how to promote their science practice through technology. Research indicates that modelling *per se* can be a scaffolding learning activity [8]. In this study, the students use a newly developed modelling tool called MySystem [7] to represent their understanding of biomagnification. We investigate the processes of students' modelling through MySystem. The research questions addressed in this study are:

1. How did students collaborate to construct computer models to represent their understanding of biomagnification? Specifically, what collaborative strategies were demonstrated by the students to facilitate what facets of learning during their collaborative modelling?
2. What were the reflections focusing on future curriculum improvements to promote students' collaborative modelling supported by technology?

1. Theoretical Background

1.1 Models and Modelling

Scientists build theories and models which are a set of simplified representations of a system to illustrate, explain and predict phenomena [2]. Through exchanging and arguing about ideas to build models the scientific community can reach commonly agreed points of view. Such process is called scientific modelling. In light of education, it is important that students learn science by exploring the world through asking questions, talking and writing about a problem, debating, building models, and investigating in order to understand natural phenomena [5]. This study focuses on the use of a technology tool to support students in building science models, i.e., the process of modelling.

1.2 MySystem: A Computer Tool as Scaffolding

Studies have shown that students were more aware of their thinking and made reasonable decisions while they interacted with instructional software [1, 4]. MySystem is a modelling tool that provides students with customized icons and arrows for students to make computer-based system models of phenomena or concepts [7]. In our study, the students used MySystem to depict their understanding of biomaganification with regard to how the leakage of radioactive elements influenced the ecology (Figure 1). MySystem scaffolds students to use multiple representations to depict biomaganification and to focus on foodchain relationships within a radiation-polluted ecology. It can make students' thinking visible, and serve as an inducer of learner discussions such as students interpreting and arguing their models.

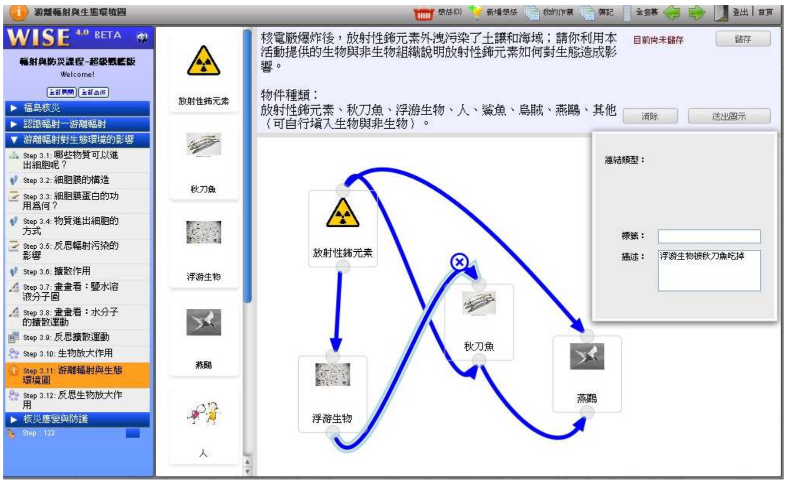

Fig. 1 A screenshot of the MySystem interface and a student's model

2. Methods

2.1 Participants

Forty-two ninth-grade students in two classes taught by the same science teacher participated in this study. The students had experiences using computers frequently but never used MySystem. The students worked in dyads (a total of 21 dyads) during the MySystem activity.

2.2 Data Collection and Analysis

We used Camtasia software to capture the computer screen of the dyads' actions and record the students' dialogues. We identified 20 segments (65% of the whole data) of the dyads' time-on-task dialogues, a total of about 80 minutes, for further analysis. It indicates that more than half of the whole data were informative. A segment is a bounded set of conversations on a coherent task and usually ends by students' end-of-task chats. We used Nvivo to aid our coding and analysis procedure. The dyads' discussions were explored in a manner consistent with Grounded Theory [3]. The first author read through the transcripts of the 20 segments in several iterations to make notes regarding strategies and facets of learning that emerged from the dyads. The emergent categories were then used to code the students' collaborative modelling processes. The third author also coded the 20 segments. The inter-coder agreement between the two coders is 98%. Inconsistent codes were discussed and resolved.

3. Results

3.1 Students' Collaborative Strategies that Mediate Learning in Computer Modelling

We identified four students' collaborative strategies that mediate three facets of learning when the students collaborated to construct computer models of biomagnification. We summarized the results in Table 1. The results were encouraging since the students' questioning, confirming, doubting, and correcting strategies indicated that they were cognitively engaged during the computer-supported modelling processes. Furthermore, we found that the students used these strategies to mediate their learning of meta-monitoring, concepts clarification, and visualizations in learning. For example, some dyads used questioning to monitor their progress, or developed conceptual understanding. Some dyads used correcting to learn the convention of visualizing biomagnifications in the form of a system model. The results showed evidence of learning benefits when engaging students in computer-supported collaborative modelling processes in that such processes facilitated learning of concepts, meta-cognition, and visualization.

Table 1 Collaborative strategies and mediated learning in the modelling process

Strategies	Description	Sample discussions
Questioning	Students raise questions when there is no clear consensus yet.	*S1: Eat...saury. Toward or backward?* *S2: Connecting saury to human being, because saury were eaten by human being [fl10030103-6]*
Confirming	Students bring up a certain view for agreement.	*S1: (Connect plankton to saury) This way?* *S2: To be preyed.* *S1: (Connect Radioactive elements to saury) Next...this way ?* *S2: Yes, the same. [fl10030103-4]*
Doubting	Students attempt to refute the original preliminary view or temporary consensus.	*S1: Squid eats salary.* *S2: No...Squid eats saury?* *S1: It did.* *S2: No. Squid just can eat small fish, it can't eat the large one. Squid does not eat saury. [fl10030103-2]*
Correcting	Students revise a certain view directly.	*S7 connect plankton to shark.* *S8: Shark does not eat plankton.* *S7: Oh! It's wrong. [fl10030308-2]*
Facets of learning	Description	Sample discussions
Meta-monitoring	Students' discussion to check the current status in light of completing the task	*S7: We have all the icons* *S8: Well...We link arrow first, then type.* *S7: Okay. [fl10030308-1]*

Concept clarification	Students' discussion to learn science concepts involved in the modelling process	*S5: What food does a shark eat?* *S6: Shark eats human being, and human being eats shark. [fl10030110-1]*
Visualization	Students' discussion to learn the convention of visualization, such as the meaning of the direction of the arrow in a food chain.	*S4 connect tern to saury.* *S3: It's wrong, it's in the reverse direction. [fl10030107-5]*

3.2 Reflections on future improvements

Although we found evidence of learning benefits of computer-supported collaborative modelling, students' discussions to reach a consensus were not deep enough. They rarely described the interaction between the biological relationship to the text. Even if the students discussed the link direction of the arrow, still more than half of the groups' models contained errors on the linkage of the trophic relations. In order to improve the quality and depth of student discussion, we may use the function of "instant feedback" to remind students of the link error and "view and critique each other" to provide students with the opportunity to discuss the advantages and disadvantages of different models, and then revise the original group model. These improvements can give a full play to the role of computer support for modelling and scaffolding.

4. Concluding Remarks

In this study, we observed that a computer modelling tool could support ninth-grade students in using questioning, confirming, doubting and correcting strategies to clarify the relationship between each object and adjust the development of the system model. Such strategies mediated students' meta-monitoring, concept clarification and visualization in learning. Just as Schwarz, Reiser, Davis and Kenyon (2009) [6] suggested that there are several challenges for cultivating students' modelling practice in class, future studies can broaden the scale to investigate students' longitudinal development of modelling knowledge and skills enhanced by computer tools.

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