Yang, J. C. et al. (Eds.) (2018). Proceedings of the 26th International Conference on Computers in Education. Philippines: Asia-Pacific Society for Computers in Education

The impact of inquiry-based instruction with inquiry map on conceptions of learning science to learning science

Chia-Jung CHANG[a*], Cai-Ting WEN[a], Li-Wen TSENG[a], Ming-Hua CHANG[a], Chen-Chung LIU[a], Shih-Hsun FAN CHIANG[a], Fu-Kwun HWANG[b]

[a]*Graduate Institute of Network Learning Technology, National Central University, Taiwan*

[b]*Department of Physics, National Taiwan Normal University, Taiwan*

*baileysrong@gmail.com

Abstract: Traditional instruction of science knowledge may lead to low motivation in science learning. Science inquiry may improve students' science concept knowledge and insights about science. However, the teaching of science inquiry is a complex process which involves multiple inquiry steps. Therefore, this study designed an inquiry map system for supporting inquiry-based instruction, and investigates the impact of the use of inquiry map system in teaching on students' conceptions of learning science. Participants were 49 junior eighth-grade students from two classes randomly one of which was assigned as experimental group (N=25) teaching with inquiry map, while the other one as control group (N=24) lectured in traditional instruction. Data collection including the questionnaires and learning test were analyzed with ANCOVA. The results showed that the use of the inquiry map system in teaching reduced students' conception of 'memorizing', and ' calculating and practicing', and enhanced the extent of 'seeing in a new way', 'deep motivation', and 'deep strategy' in learning sciences.

Keywords: inquiry-based instruction, computer simulations, conceptions of learning science, approaches to learning science

1. Introduction

Science inquiry has become essential ability in the 21st century. It helps students construct science concept through science practice such as observing, experiment, and analyze (NRC, 2011). Inquiry-based instruction narrows down the achievement gap of learning science, not only improves learners' concept knowledge, but also helps students gain the insights about science (Bilgin, Karakuyu, & Ay, 2015). However, previous studies indicated that students experienced difficulty without guidance during the inquiry process, and the difficulties they encountered during the inquiry may have negative effect on the attitude to science learning (Jiang, & McComas, 2015).

Inquiry-based instruction is highly complex pedagogy act (Bilgin et al., 2015). One of the obstacle to apply the inquiry-based instruction is the time constraint as it requires students to go through each of the inquiry process including observation, experiment and analysis which consume more time than regular lecture (Fitzgerald, Danaia, & McKinnon, 2017; Tairab, & Al-Naqbi, 2017). Therefore, even the inquiry-based instruction has been advocated to enhance science learning, teachers tend to lecture in the traditional teacher-center way (Koksal, Berberoglu, 2014), which viewed transferring knowledge and passing assessment as the most important goal. In such a teaching context, students often hold low level of learning motivation to in learning sciences (Tairab, & Al-Naqbi, 2017).

Hence, this study designed an inquiry map system as a supporting tool for teacher to integrate science inquiry into instruction. Each inquiry step and the relationship between two steps is clearly displayed via inquiry map system. It is expected to facilitate learners to reflect on the inquiry process, and improve their attitude of students to science learning. A pilot experiment was conducted to discover the impact of the instruction with inquiry map. The research questions of this study is:

- What is the impact of the use of the inquiry map system in teaching on student's conceptions of learning science?

2. Method

2.1 Participants and the modeling-based instruction

A quasi-experimental design was conducted to investigate the effect of inquiry map system instruction on learning science. The participants of this study, aging from 14 to 15, were 49 eighth-grade students from two classes in northern Taiwan. One of the intact classes was randomly assigned to control group (N=24) while the other is experimental group (N=25). The two groups were taught by the same teacher with an interactive whiteboard. They were divided into teams of 3-5 students to complete learning tasks. None of the students in both groups had learned Buoyancy related knowledge in science course, and neither had experience about using computer simulation and the inquiry map system. Thus, these students are suitable as participants for this study to investigate the effect of the instruction with inquiry map on students' perceptions of learning science.

2.2 The inquiry map instruction and procedure

Both control and experimental groups learned the same concept of buoyancy, including the definition of buoyancy, the cause of floating and sinking, and the factors affecting buoyancy. The control group received the tradition instruction in which the teacher lectured with the textbook. Students had to complete the learning sheet designed by the teacher. The major content of learning sheet consisted of the guidance on experiment steps, data collection and record, and great number of exercises. The teacher demonstrated the hands-on buoyancy experiment in the class. However, students were asked to collect data and record on the learning sheet, and completing the exercises.

On the other hand, the teacher instructed for the experiment group using the inquiry map system. Teacher demonstrated the inquiry map in advance to guide students to experience each phase of science inquiry. The goal of the use of the map is to promote students' awareness about the science inquiry process. The teacher pre-designed the teaching materials using the inquiry map system which divided the key concepts of the buoyancy into the main inquiry steps: including generating question, designing experiment, collecting and analyzing data, and forming conclusions. Each student team would be equipped with an iPad, and use it to design and conduct experiment by the buoyancy simulation provided by this study. Students were asked to record data collected from the simulation on the learning sheet. The student teams had to discuss and form conclusions based on the experiment results.

A questionnaire of conceptions of learning science was given to both experiment and control groups before and after the intervention. The duration of instruction to both groups was four sessions (45 minutes per session).

2.3 Instruments

2.3.1 Inquiry map system design

The study developed an inquiry map system based on web-based collaborative simulation (Chang, et al., 2017) to support inquiry-based instruction. The system was designed for enhancing students' meta-cognition of inquiry process, followed the principles proposed by Järvelä et al. (2015). The inquiry map system provided instructors with control panel (the middle part of Fig. 1), referred as inquiry map, for supporting and developing material of inquiry-based instruction. Each node with different shape on the map represents one of the corresponding inquiry phases. For instance, the circular node represents the formulating questions and hypotheses phase, and the trapezoidal node represents the designing experiments phases. Nodes of different inquiry phases on the map could be created by following the inquiry process. Furthermore, the system would generate links between two nodes automatically. It displays the inquiry cycle in a visual manner, which helps students build the awareness of inquiry process.

In addition, a detailed page with guidance of inquiry phase would be shown when the teacher clicked the node, supporting the teacher to guide students to go through each phase (the left part and the right part of Fig. 1). For example, when the teacher creates a node of designing experiments, an unique page would be generated at the same time, providing information of relevant experiment variables and the input box for recording the values would be provided to the students to conduct the experiment in next phase.

It should be noted that the teacher could create new node, formulating questions and hypotheses, for restarting inquiry cycle with different questions and hypotheses. Therefore, students could follow the inquiry process designed by the teacher to participate in the inquiry activity.

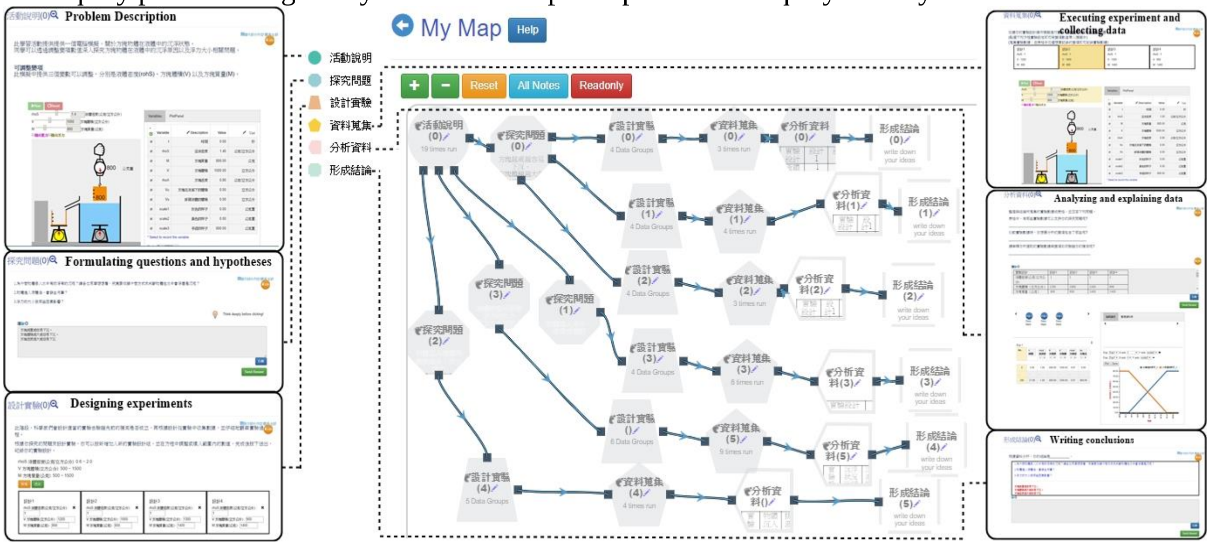

Figure 1. The modeling map system to support modeling-based learning

The types of the nodes which represent each of the inquiry phase are detailed as followed:

- Problem description (top of the left part in Fig. 1): Such a page consists of the description of the task, in which the teacher introduced the buoyancy inquiry context and described the learning task and demonstrated the simulation.
- Formulating questions and hypotheses (middle of the left part in Fig. 1): A page supported the teacher to guide students to select the inquiry question of interest and generate their hypothesis. That is, the teacher would ask students to select one of the hypotheses from candidate questions. Example inquiry questions the teacher provided are “In the condition of the same volume, the heavier is the mass, the greater is the Buoyancy.”, and “In the condition of the same mass, the larger is the volume, the greater is the Buoyancy.”
- Designing experiments (bottom of the left part in Fig. 1): The page supports the teacher guide students design experiment. Relevant variables required in the experiment would be displayed.
- Executing experiment and collecting data (top of the right part in Fig. 1): Such a page displays the buoyancy simulation, Students were guided to conduct experiment by manipulating the simulation with the designed experiments, and collected data for verifying their inquiry questions.
- Analyzing and explaining data (middle of the right part in Fig. 1): This page displays data recorded in previous phase, and provide tool for students to organize, analyze and explain data, such as generating chart to understand the relationship between any two variables.
- Writing conclusions (bottom of the right part in Fig. 1): Such a page supports the teacher to guide students to reflect upon the experiment result and their response on the hypothesis selected from the beginning, and write down their conclusion. If the result is not consistent with the pre-identified hypothesis, the teacher would guide students to restart a new inquiry cycle based on the conclusion.

2.3.2 Questionnaire

The conceptions of learning science (COLS) questionnaire, developed by Lee, Hohanson, and Tsai (2008), was applied to investigate participants' perceptions of learning science before and after the learning activity. The questionnaire is presented in a five-point Likert scale. It consists of seven dimensions, including memorizing (8), testing (7), calculating and practicing (6), increase of knowledge (7), applying (6), understanding (6), and seeing in a new way (6). The over Cronbach's alpha value of COLS was .82, indicating that the questionnaire were sufficiently reliable.

2.3.3 Data analysis

To explore the effect of the modeling map system and traditional instruction on students' perceptions of learning science, an analysis of one-way covariance (ANCOVA) was used to compare the perceptions of the two groups. The ANCOVA using the pre-test scores as the covariate compared the post-test scores of the two groups in terms of the questionnaire result of participants' conceptions of learning science.

3. Results and discussions

3.1 Student's conceptions of learning science

Table 1 shows that the result of the control and experimental groups students' perceptions on the COLS questionnaire with ANCOVA. The results display that experimental group had a significantly lower extent of using memorizing ($F(1, 47)=4.18$, $p<.05$) to learning science than control groups did. Although the control group held a lower extent of using calculating and practicing to learning science ($F(1, 47)=3.49$, $p=.068$) and higher extent of conception of seeing in a new way ($F(1, 47)=3.06$, $p=.087$), the differences were only marginally significant. The results implied that inquiry map system instruction may improve participants' conceptions of learning science in 'memorizing' and 'calculating and practicing', and 'seeing in a new way'.

Table 1. The result of the two groups' conceptions of learning science

COLS	Group	N	Adjusted Mean	Std. err.	*F*	*p*
Memorizing	Control	24	3.23	.09	4.18*	.047
	Experimental	25	2.96	.09		
Testing	Control	24	3.12	.11	2.46	.124
	Experimental	25	2.89	.10		
Calculating and practicing	Control	24	3.46	.10	3.49	.068
	Experimental	25	3.21	.10		
Increase of knowledge	Control	24	3.45	.10	.39	.535
	Experimental	25	3.54	.09		
Applying	Control	24	3.25	.10	2.52	.119
	Experimental	25	3.48	.10		
Understanding	Control	24	3.53	.10	.39	.534
	Experimental	25	3.62	.10		
Seeing in a new way	Control	24	3.40	.10	3.06	.087
	Experimental	25	3.65	.10		

$*p<.05$

4. Conclusion

This study developed an inquiry map system for supporting instructors to integrate inquiry with science instruction as an attempt to improve students' perception of learning science. To discover the influence of the instruction with the system, the difference of the conceptions of learning science between traditional and the proposed instructional approach were compared. The results showed that students received inquiry map system instruction held a lower extent of using ‘memorizing’ and ‘calculating and practicing’, and a higher extent of using ‘seeing in a new way’ when learning science than those in the traditional instruction. The results reflect that teaching with inquiry map has positive influence on improving students’ perception of science. It is hopeful to help teacher guide students to doing inquiry with inquiry map system for accessing more concrete inquiry ability. However, how the perception of science was improved and their learn progress during the instruction with inquiry map system is still not clear. Therefore, further investigation is still required to understand the interactions of the inquiry-based instruction and the assessment.

Acknowledgements

This research was partially funded by the Ministry of Science and Technology under contract numbers 104-2511-S-008-014-MY3, 106-2811-S-008-001, and 106-2511-S-008-012-MY3.

References

Bilgin, I., Karakuyu, Y., & Ay, Y. (2015). The effects of project based learning on undergraduate students’ achievement and self-efficacy beliefs towards science teaching. *Eurasia Journal of Mathematics, Science & Technology Education, 11*(3), 469-477.

Chang, C. J., Chang, M. H., Chiu, B. C., Liu, C. C., Chiang, S. H. F., Wen, C. T., ... & Wu, S. W. (2017). An analysis of student collaborative problem solving activities mediated by collaborative simulations. *Computers & Education, 114*, 222-235.

Fitzgerald, M., Danaia, L., & McKinnon, D. H. (2017). Barriers inhibiting inquiry-based science teaching and potential solutions: perceptions of positively inclined early adopters. *Research in Science Education*, 1-24.

Järvelä, S., Kirschner, P. A., Panadero, E., Malmberg, J., Phielix, C., Jaspers, J., ... & Järvenoja, H. (2015). Enhancing socially shared regulation in collaborative learning groups: designing for CSCL regulation tools. *Educational Technology Research and Development, 63*(1), 125-142.

Jiang, F., & McComas, W. F. (2015). The effects of inquiry teaching on student science achievement and attitudes: Evidence from propensity score analysis of PISA data. *International Journal of Science Education, 37*(3), 554-576.

Lee, C. B., Jonassen, D., & Teo, T. (2011). The role of model building in problem solving and conceptual change. *Interactive Learning Environments, 19*(3), 247-265.

Lee, M. H., Johanson, R. E., & Tsai, C. C. (2008). Exploring Taiwanese high school students' conceptions of and approaches to learning science through a structural equation modeling analysis. *Science Education, 92*(2), 191-220.

National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. National Academies Press.

Tairab, H., & Al-Naqbi, A. (2017). Provision of Inquiry Instruction and Actual Level of Practice as Perceived by Science Teachers and their Students. *Eurasia Journal of Mathematics, Science and Technology Education, 14*(1), 397-412

Koksal, E. A., & Berberoglu, G. (2014). The effect of guided-inquiry instruction on 6th grade Turkish students' achievement, science process skills, and attitudes toward science. *International Journal of Science Education*, *36*(1), 66-78