The Development and Evaluation of the Online Science Fair Inquiry System based on Scaffolding Design

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Abstract: Science fair is one of the most common open inquiry activities which can facilitate learners to construct their science knowledge and develop science literacy in school. However, there are a great deal of difficulties and challenges in Taiwan's science fair. For example, novice teachers may neither effectively guide learners to conduct science fair inquiry activities nor facilitate learners to construct related knowledge. To scaffold teachers' instruction and students' learning in science fair inquiry effectively, the "Online Science Fair Inquiry System based on scaffolding design" (OSFIS v 2.0) adapted from (OSFIS v 1.0) was developed in this study. After the development of the system, this study also conducted a series of system evaluations on it. To this end, questionnaire survey was conducted. The participants of the system evaluation in this study were 61 elementary school teachers. The participants expressed highly satisfactory perceived usefulness on teachers' and students' scaffolding design. Also, they had high intention to use the OSFIS v 2.0. Moreover, this study reveals that the system may facilitate both teachers and students to understand the process of science fair inquiry, solve the limitation of activities times, record the portfolio during inquiry activities, and complement teachers' professional knowledge. Finally, some suggestions and implications for teachers to conduct open inquiry activities, system design, and future work are also proposed.

Keywords: Science fair; Inquiry; Online Science Fair Inquiry System, Technology-enhanced inquiry tool; Scaffolding

1. Introduction

There is no doubt that inquiry is the core of modern science education. The major educational goal of inquiry-based teaching or inquiry-based instruction is to help learners study science inquiry skills and enhance the understanding of science inquiry (NRC, 2000). In general, there are five stages of an inquiry activity in science classroom; namely questioning, planning, implementing, concluding, and reporting (Lee et al., 2006). According to the openness of inquiry activities, Bell et al. (2005) categorized four different levels of inquiry activities: confirmation, structured inquiry, guided inquiry, and open inquiry. For science educators, K-12 students are expected to be able to conduct open inquiry. In practice, science fair is the most common open inquiry activity in science classrooms. In many countries, science fair is adopted to help student learn science (Bencze & Bowen, 2009). However, the literature revealed that many teachers may lack of professional knowledge, time, recourses, and assistance when conducting science fair instruction (Anderson, 2002). Only few science teachers know how to guide students to conduct science fair projects or inquiry activities effectively (Justi & Gilbert, 2002). In particular, in recent years, lower quality of the science fair projects conducted by elementary school students have been found in Taiwan. Therefore, how to scaffold elementary school teachers' instruction and students' learning in conducting science fair projects is crucial for educators.

Recently, various technology-enhanced inquiry tools have been developed to scaffold inquiry activities for different science users, activities, and openness (Chung, 2012). For user type, IQWST (Investigating and Questioning our World through Science and Technology) and WISE (Web-based Inquiry Science Environment; Linn et al., 2003) were developed for scaffolding inquiry activities in junior and senior high school science curriculum while OSFIS v.1.0 (Online

Science Fair Inquiry System v.1.0; Chung; 2012) was specifically developed for elementary science fair. For the inquiry activity type, IQWST was mainly for in-class inquiry, WISE was not only for in-class inquiry but online inquiry and experimental inquiry. And the OSFIS v.1.0 was for science inquiry which was different from IQWST and WISE. And for the degree of the openness, IQWST was structured inquiry, WISE was guided inquiry, and the OSFIS v.1.0 was learner-centered open inquiry. However, technology-enhanced inquiry tool for scaffolding elementary science fair inquiry especially based on scaffolding design is still not yet available. In order to scaffold elementary school science teachers' science fair instruction and students' learning in science fair inquiry, this study aimed to develop a new "Online Science Fair Inquiry System" (OSFIS v 2.0) based on scaffolding design. After the development of the OSFIS v 2.0, this study also conducted a series of system evaluations on it.

2. System development

2.1 Participants of system development

The OSFIS v 2.0 developed in this study aimed to provide a platform for elementary teachers who are interested in personal professional development regarding science fair instruction. They can enhance their professional knowledge by using this platform to guide learners to conduct science fair inquiry activities or facilitate learners to construct related knowledge. The development of this system is coordinated by science education and e-learning researcher, in-service science teacher, and system designer. By combining researcher's professional knowledge and in-service teacher's practical experience with system designer's software skills the system design therefore can be more practical for teachers to use.

2.2 System flow chart

In order to help teachers conduct science fair effectively, five inquiry stages suggested by Lee et al. (2006) are included in this system. As shown in Fig. 1, the student flow chart is composed of a series instruction module. Once the students finish each stage of science fair inquiry, they can submit their work to the work reviewing module. If teacher approves the stage, then students can move on to the next one. If not, they need to revise their work according to their teacher's comments and resubmit their revised work. After students finish the five stages, they have completed a science fair project.

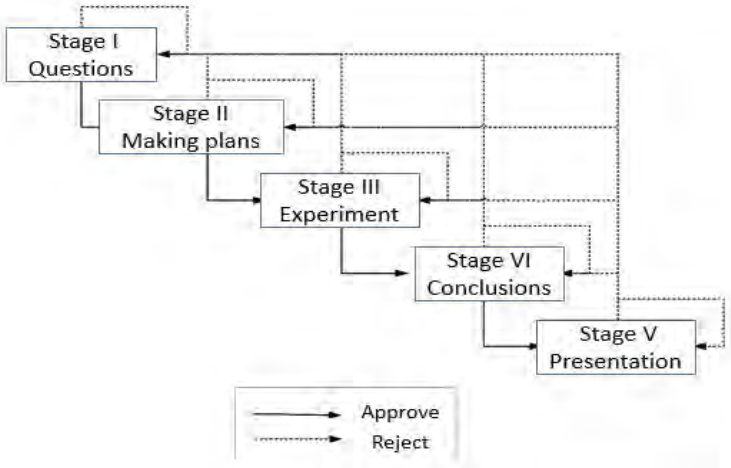

Figure 1. System flow chart

2.3 System framework

The system framework of the OSFIS v 2.0 consists of five main modules and six databases. The six databases store science expert knowledge, student science fair mission, group discussion, interaction, reflection, and user information database. The five modules include user information, interaction and reflection, collaboration, science fair project, and teacher supervision module.

2.4 Modification of Student's and teacher's modules

As shown in Fig. 2, the functions derived from OSFIS v 1.0 are presented with a solid line while new functions of OSFIS v 2.0 are presented with a dotted line. In OSFIS v 2.0, "SF Knowledge" (Science Fair Knowledge) is departed from "SF Management" (Science Fair Management) which may assist students acquire more science fair knowledge. "Learning Process" is also added to help students monitor all learning activities that may help students view their own learning process, including "Previous awarded science fair projects", "Result History", "Grading History", "Log book History", "Discussion History", and "Reflection History". More functions which may help students collaborate and interact with others are added, such as "Sharing Data", "Acquiring Comments", "Acquiring Replied Hints", "Teachers' Hints", "Account Registration", and "Add groups".

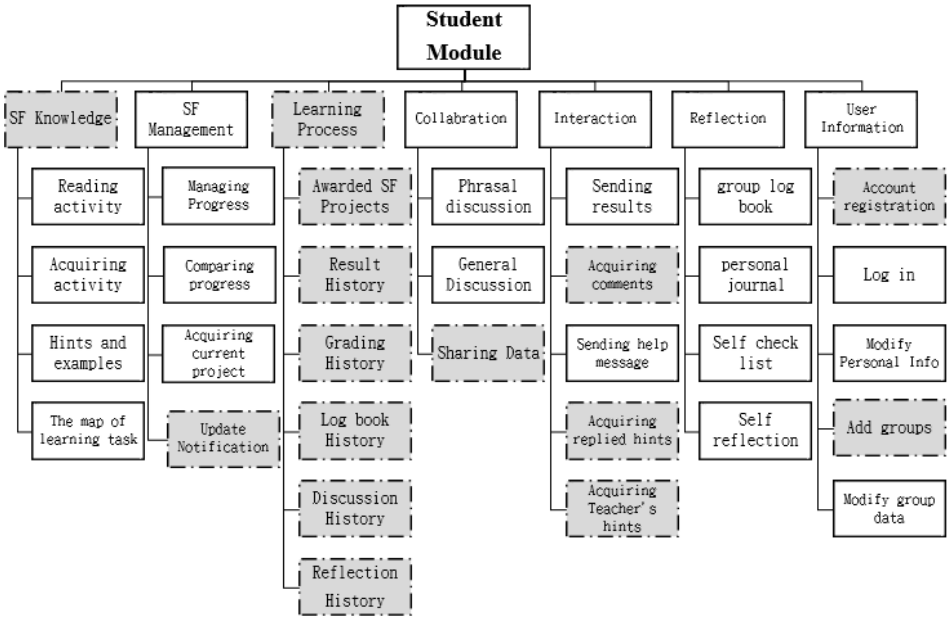

Figure 2. The comparison of student module between OSFIS v 1.0 and v 2.0

For teacher module, as shown in Fig. 3, the functions derived from OSFIS v 1.0 are presented with a solid line while new functions of OSFIS v 2.0 are presented with a dotted line. In OSFIS v 2.0, "SF Knowledge" (Science Fair Knowledge) is departed from "SF Management" (Science Fair Management). Within this module, two more functions, "Read awarded SF projects" and "Add related links" and are added in order to help teachers acquire more science fair knowledge. In "Monitoring & Management module", group modification is added. Teachers can modify groups' learning status according to their progress. "Teaching module" is a brand new module which may help teachers review instructional records. In addition, three more functions, "Remind learning progress", "Project Evaluation", and "Add friends" are added in OSFIS v 2.0. Teachers have the privilege to remind students with their learning progress and they can also evaluate each project's phrasal outcome anytime. Teachers can view other teachers' science fair projects by adding them as good friends.

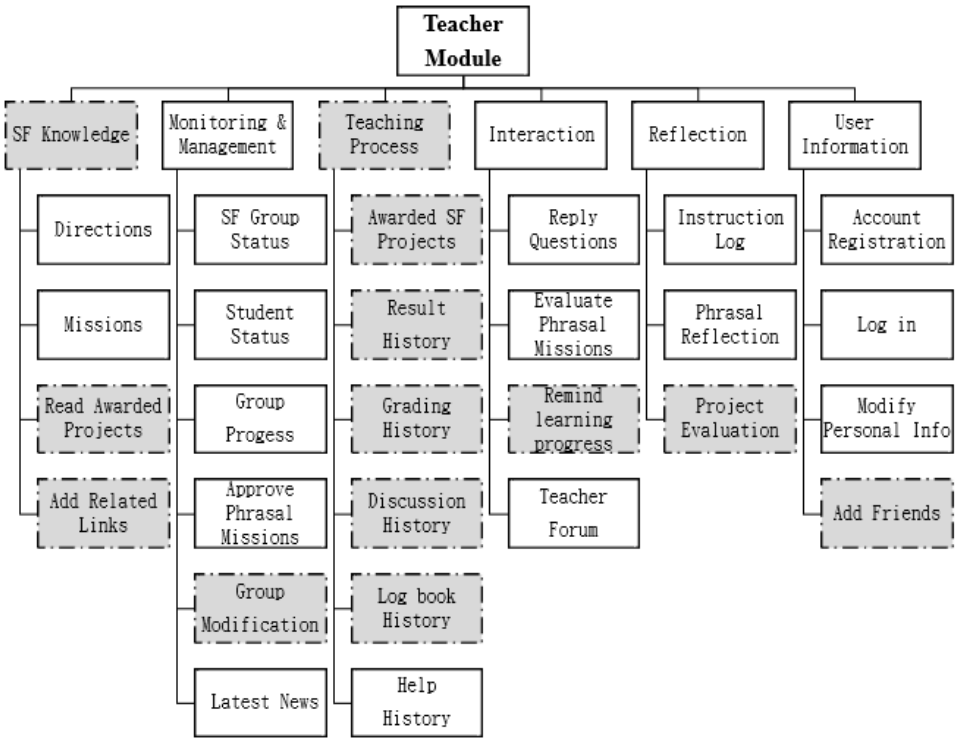

Figure 3. The comparison of teacher module between OSFIS v 1.0 and v 2.0

2.5 Student/ Teacher module and scaffolds

The system is designed to help teachers guide students to conduct science fair projects or inquiry activities by adding scaffolds. As a result, it is necessary to elaborate the connection between the system modules and the scaffolds. The relations between student /teacher module and scaffolds are showed as follows: Teacher's module and scaffolds (Table 1), Student's module and scaffolds (Table 2):

Table 1: Teacher module and scaffolds

Scaffolds	Content	Teaching Challenges	System Modules
Teacher Conceptual scaffolds (TCS)	Offering related Knowledge of Science Fair instruction	Teachers do not understand science fair's relevant knowledge and structure.	Teaching knowledge module
Teacher Procedural Scaffolds (TPS)	The procedure of inquiry instruction	Teachers do not know how to Conduct science fairs.	Inquiry structure
Teacher Metacognitive Scaffolds (TMS)	Making plans	Teachers do not know how to make Instruction plans	Monitoring & Management module & Teaching module
	Monitoring and adjustment	Teachers do not know how to monitor their instructional process	
		Teachers do not know how to make sure students can finish phrasal learning missions.	
		Teachers do not know how to help students modify phrasal missions in order to achieve learning goals	
		Teachers cannot monitor students'	

		learning process	
	Reflection	Teachers do not know how to Reflect their teaching abilities	Reflection module
Teacher Strategic Scaffolds (TSS)	Teacher-student interaction	Teachers increase the chances to interact with students asynchronously	Interaction module
	Peer interaction	Teachers share their progress with other teachers	

Table 2: Student module and scaffolds

Scaffolds	Content	Teaching Challenges	System Modules
Student Conceptual scaffolds (SCS)	Offering related Knowledge of Science Fair instruction	Students do not understand science fair's relevant knowledge and structure.	Teaching knowledge module
Student Procedural Scaffolds (SPS)	The procedure of inquiry instruction	Students do not know how to Conduct science fairs.	Inquiry structure
Student Metacognitive Scaffolds (SMS)	Making plans	Students do not know how to make Instruction plans	Monitoring & Management module & Teaching module
	Monitoring and adjustment	Students do not know how to monitor their instructional process	
		Students do not know how to finish phrasal learning missions effectively.	
		Students do not know how to adjust phrasal missions in order to achieve learning goals	
		Students cannot focus on the current learning tasks	
	Reflection	Students do not know how to reflect their learning tasks	Reflection module
Student Strategic Scaffolds (SSS)	Peer interaction	Group leaders need to arrange tasks Group members need positive interaction	Group collaboration module
	Teacher-student interaction	Students have difficulties learning tasks	Teacher-student interaction module

3. Methodology (System evaluation)

3.1 Participants

The participants of this study consisted of 61 elementary teachers (20 males and 41 females) whose teaching experience ranged from 1 to 32 years, with an average of 15.81 years. 38 (62.3%) teachers had the experience of instructing science fairs. 21 (34.4 %) teachers had no experience of instruction. In general, most participant teacher in this study did not have enough science fair instructional experience which was perfect for this system evaluation.

3.2 Instruments

In this study, the participant teachers' perceived usefulness and usability of the OSFIS v 2.0 as well as their willingness of using the OSFIS v 2.0 were evaluated. To this end, the 6 Likert-scale questionnaire developed in Yuen & Ma (2008) was adapted and used in this study. The modified instrument consists of three scales: usefulness (5 items), usability (5 items), and willing of use (4 items). All the alpha reliability values of the three scales are greater than 0.8, and the overall alpha reliability value of the instrument is 0.96 (Table 3).

Table 3: Item numbers, reliability, and sample items of the instrument scales

Scale	Item	α	example item
ITU	5	0.93	I would like to use OSFIS to conduct science fair.
PU	5	0.96	I find using OSFIS can enhance my teaching.
PEOU	4	0.94	It is easy for me to master the operation of OSFIS.

ITU, Intention to Use; PU, Perceived Usefulness; PEOU, Perceived Ease of Use)
Over all α = 0.96

3.3 Data collection

There were three phases of data collection. In the first phase (30 minutes), the authors gave directions of five stages of learning tasks, system operations, and student interface, and teacher interface of the system. In the second phase (30 minutes), teachers freely explored the scaffolding design, student interface, and teacher interface. In the last phase (10 minutes), overall system evaluation, usability of learning tasks and scaffolding design, and teachers' feedback were evaluated by using a questionnaire developed in this study (Fig 4).

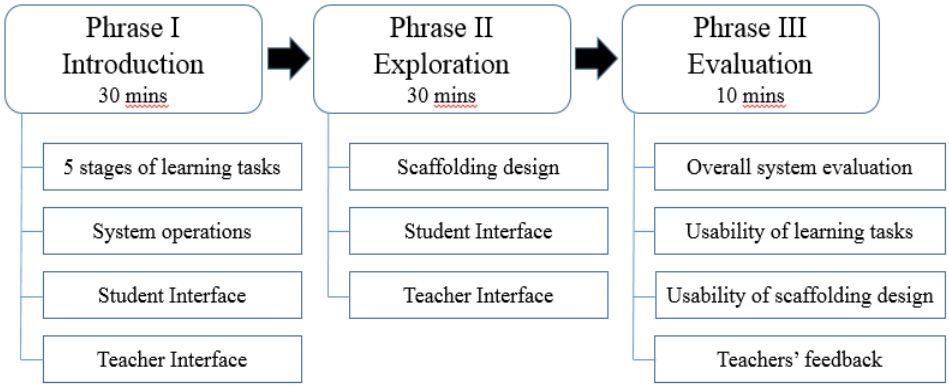

Figure 4. Data collection procedure

4. Major findings and Conclusions

4.1 Major findings

Table 4 shows that the teachers' average scores on perceived usability of teachers' scaffolds are between 4.80 to 4.92. The result was higher than the 6 Likert scale average score (i.e., 3.5).
It indicates that participants in this study perceived high usability on teachers scaffolds.

Table 4: Teachers' average scores on perceived usability of teachers' scaffolds (n=61)

Scaffolds	Mean	S.D.
Teacher conceptual scaffolds（TCS）	4.98	0.66
Teacher procedural scaffolds（TPS）	4.90	0.78
Teacher metacognitive scaffolds（TMS）	4.91	0.76
Teacher strategic scaffolds（TSS）	4.90	0.77
Overall	4.92	0.69

Table 5 shows that the teachers' average scores on perceived usability of students' scaffolds are between 4.90 to 4.98. The result was also higher than the 6 Likert scale average score (i.e., 3.5). It indicates that the participants in this study generally held positive attitude toward the system and were willing to use it.

Table 5: Teachers' average scores on perceived usability of students' scaffolds (n=61)

Scaffolds	Item	Mean	S.D.
Student conceptual scaffolds（SCS）	4	4.83	0.77
Student procedural scaffolds（SPS）	3	4.92	0.81
Student metacognitive scaffolds（SMS）	6	4.83	0.76
Student strategic scaffolds（SSS）	5	4.80	0.76
Overall	18	4.83	0.71

4.2 Conclusions

To scaffold teachers' instruction and students' learning in science fair inquiry, the "Online Science Fair Inquiry System" (OSFIS v 2.0) based on scaffolding design was developed in this study. After the development of the system, this study also conducted a series of system evaluations on it. The participants expressed satisfactory perceived usefulness and ease of use of the system. Also, they had high intention to use the OSFIS v 2.0. Moreover, this study reveals that the OSFIS based on scaffolding design may facilitate both teachers and students to understand the process of science fair inquiry, solve the limitation of activities times, record the portfolio during inquiry activities, and complement teachers' professional knowledge. Some teachers also gave concrete suggestions of the system design which may be provided as the future revision of the system. Based on the findings in this study, the OSFIS v 2.0 may be improved and applied to different levels of school in the future work.

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References

Abd-El-Khalick, F., BouJaoude, S., Duschl, R., Lederman, N. G., Mamlok-Naaman,R., Hofstein, A., Niaz, M. Treagust, D., Tuan, H.-L.. (2004). Inquiry in science education: International perspectives. *Science Education*, *88*(3), 397 – 419.

Abernethy, K., Gabbert, P. & Treu, K. (1998). Inquiry-Based Computer Science Instruction : Some Initial Experiences. *In Proceedings of the 3rd Conference on Integrating Technology into Computer Science Education and on 6th Annual Conference on the Teaching of Computing*, pp.14-17. Ireland.

Anderson, R. D. (2002). Reforming science teaching: What research says about inquiry. *Journal of Science Teacher Education, 13*(1), 1-12.

Banchi, H. & Bell, R. (2008). The Many Levels of Inquiry. *Science and Children*, *46*(2), 26-29.

Bencze, J.L., & Bowen, G. M. (2009). A national science fair: Exhibiting support for the knowledge economy. *International Journal of Science Education, 31*(18), 2459-2483.

Chinn, C. A., & Malhotra, B. A. (2002). Epistemologically authentic inquiry in schools: A theoretical framework for evaluating inquiry tasks. Science Education, *86*(2), 175 – 218.

Flick, L., & Bell, R. (2000). Preparing tomorrow's science teachers to use technology: Guidelines for science educators. *Contemporary Issues in Technology and Teacher Education, 1*(1), 39 – 60.

Justi, R. & Gilbert, J.K. (2002). Modelling, teachers' views on the nature of modelling, and implications for the education of modellers. *International Journal of Science Education, 24*(4), 369–387.

Hamelin, D. (2004). *Searching the Web to Develop Inquiry and Collaborative Skills*. Annual Joint

Conference Integrating Technology into Computer Science Education. Working group reports from ITiCSE on Innovation and technology in computer science education, United Kingdom.
Hill, J. R. & Hannafin, M. J. (2001). Teaching and learning in digital environments: The resurgence of resource-based learning. *Educational Technology, Research and Development, 49*(3), 37-52.
Kim, M. C., Hannafin, M. J., & Bryan, L. A. (2007). Technology-enhanced inquiry tools in science education: An emerging pedagogical framework for classroom practice. *Science education, 91*(6), 1010-1030.
Kyza, E. A., Constantinou, C. P., & Spanoudis, G. (2011). Sixth graders' co-construction of explanations of a disturbance in an ecosystem: Exploring relationships between grouping, reflective scaffolding, and evidence based explanations. *International Journal of Science Education*, 33, 2489–2525. doi: 10(1080/09500693),2010,550951.
Land, S. M., & Greene, B. A. (2000). Project-based learning with the World Wide Web: a qualitative study of resource integration. Educational Technology *Research and Development, 48*(1), 45–67.
Mayer, R. E. (1998). Cognitive, metacognitive, and motivational aspects of problem solving. *Instructional science, 26*(1), 49-63.
Mettas, A. C., & Constantinou, C. C. (2008). The Technology Fair: a project-based learning approach for enhancing problem solving skills and interest in design and technology education. *International Journal of Technology and Design Education, 18*(1), 79-100.
National Research Council. (2011). The national science education standards. Washington, DC: National Academy Press.
Reiser, B. J. (2004). Scaffolding complex learning: The mechanisms of structuring and problematizing student work. *Journal of the Learning Sciences, 13*(3), 273 – 304.
Reiser, B. J., Tabak, I., Sandoval, W. A., Smith, B. K., Steinmuller, F., & Leone, A. J. (2001). BGuILE: Strategic and conceptual scaffolds for scientific inquiry in biology classrooms. In S. M. Carver & D. Klahr (Eds.), *Cognition and instruction: Twenty-five years of progress* (pp. 263–305). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.
Slotta, J.D. (2004). The Web-based Inquiry Science Environment (WISE): Scaffolding Knowledge Integration in the Science Classroom. In M.C. Linn, P. Bell and E. Davis (Eds). *Internet Environments for Science Education*. 203-232. Lawrence Erlbaum & Associates.
Windschit, M. (2004). Folk theories of inquiry: How preservice teachers reproduce the discourse and practices of an atheoretical scientific method. *Journal of Research in Science Teaching, 41*(5), 481-512.
Yuen, AHK & Ma, WWK (2008). Exploring teacher acceptance of e-learning technology. *Asia-Pacific Journal of Teacher Education, 36*(3): 229–243.