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Collaborative Action Research on Technology Integration for Science Learning

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Abstract This paper briefly reports the outcomes of an action research inquiry on the use of blogs, MS PowerPoint [PPT], and the Internet as learning tools with a science class of sixth graders for project-based learning. Multiple sources of data were essential to triangulate the key findings articulated in this paper. Corresponding to previous studies, the incorporation of technology and project-based learning could motivate students in self-directed exploration. The students were excited about the autonomy over what to learn and the use of PPT to express what they learned. Differing from previous studies, the findings pointed to the lack information literacy among students. The students lacked information evaluation skills, note-taking and information synthesis. All these findings imply the importance of teaching students about information literacy and visual literacy when introducing information technology into the classroom. The authors suggest that further research should focus on how to break the culture of "copy-and-paste" by teaching the skills of note-taking and synthesis through inquiry projects for science learning. Also, further research on teacher professional development should focus on using collaboration action research as a framework for re-designing graduate courses for science teachers in order to enhance classroom technology integration.

Keywords Science learning · Technology integration · Elementary education · Teaching/learning strategies · Pedagogical issues

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Introduction

A major goal of science education is to enhance students' understanding of the science concepts and their construction of scientific knowledge. Children learn in different ways with differences in their motivation and engagement with learning tasks (McPherson 2009). McPherson believes all children can learn if learning activities are designed to trigger their motivation and ownership in controlling the learning process. Yore et al. (2003) encouraged practicing teachers to utilize constructivist approaches, such as project-based learning) into science inquiry teaching. Constructivism, as a learning theory, emphasizes learning occurs in context in which learners are active constructors of knowledge. Constructivists view knowledge construction as a process of engaging learners in higher order thinking through dialectic conversations with others. Reflecting the spirit of constructivism, project-based learning [PBL] as an instructional approach involves students in self-directed investigation of worthy issues (Grant 2002; Marx et al. 1997).

In the model of PBL, teachers facilitate but do not direct student learning. Students are involved in constructive inquiry which can facilitate student knowledge construction and transformation (Thomas 2000). By allowing students to construct personally-meaningful products to demonstrate what they learned, PBL enables the expression

of student diversity. The focus on student autonomy, collaborative learning, and authentic performance assessments is a key element of PBL. Given more autonomy over what they learn, students might take more responsibility for their learning. The autonomy can also maintain the interest and the motivation of students. As Thomas concluded in his review of research on PBL, PBL is a beneficial and effective instructional approach that can improve student attitudes toward learning.

The use of advanced technologies can support the process of constructive inquiry in PBL. The incorporation of technology and constructivist approach can positively influence students' understanding of science and their attitude toward science learning (Su 2008). Technology can add new dimensions to the teaching effectiveness by enabling teachers to do things that might not be possible in a traditional classroom (Churchill 2009). For example, a blog could be a useful type of educational technology (Churchill 2009; Kerawalla et al. 2009). Students can use blogs to publish their own writings, discuss topics of interest, peer review each other's work, and collaborate on projects. The use of blogs creates the possibilities for student–student/teacher-student interactions beyond the confines of a classroom. Churchill's (2009) study pointed out blogs were effective in facilitating technology and contributing to student learning. Barak and Dori (2005) advocated students could use information technology for authentic, constructive inquiry in ways that might not be possible in a traditional classroom. Therefore, technology, as a mind tool, has unique and promising potential in effective implementation of PBL (Marx et al. 1997). The incorporation of technology and PBL can foster student-directed scientific inquiry and enhance understanding of scientific concepts.

The real challenge is how technology is used by classroom teachers and students rather than technology per se. For example, Savoy et al. (2009) conducted a study to explain when PowerPoint should be used for maximum retention. They concluded PowerPoint presentations might have advantages over traditional presentation if students were asked to retain complex graphics, animation, and figures. Savoy et al. also found students preferred PowerPoint presentations over traditional presentations. In fact, there is a continuous debate over the use and benefits of PowerPoint in lecture-based classroom settings. PowerPoint as a presentation tool is advocated to improve learning by making presentations more structured and interesting to students. There are studies examining the benefits of teachers' using PowerPoint as a presentation tool in a lecture-based classroom setting (e.g. Bartsch and Cobern 2003; Burke et al. 2009; Clark 2008; Kinchin 2006; Savoy et al. 2009). However, there is little research looking into the influences of PowerPoint on students learning if it is used by students as a learning tool rather then by teachers as a presentation tool.

The benefits of incorporating technology into classrooms depend on teachers' intelligent use. Savoy et al. (2009) point out the debate over the educational value of technology highlights the need of systematic evaluation concerning how well technology achieves the goal of improving learning. Technology is viewed as a way to provide the flexibility for accommodating student learning. Appropriate use of technology enables teachers to create a flexible learning environment to meet the different needs of students in their science learning. Therefore, teachers must be aware of the affordances of technology that match appropriate learning activities for students to achieve their learning goals (Churchill 2009; Clark 2008; Kerawalla et al. 2009; Marx et al. 1997). Further, teachers are expected to prepare their students with technology skills for productive lives in a technology-rich society. When students use technology in their learning they are likely to enhance their own technology skills (Dawson et al. 2006). That is, teachers should encourage students to be creative by using technologies as tools in their learning.

Based on the above discussion, the aim of this paper is to report the outcomes of an action research inquiry concerning the incorporation of technology and project-based learning into a science class of sixth graders. Under the study, the students used the Internet, blogs and MS PowerPoint to complete the project of their choice. The research questions are as follows: (1) How does the new approach affect student learning? and (2)What learning needs are ignored regarding the use of technologies as learning tools?

Method

The impetus for the inquiry in this study originally came from the sub-teacher's conversation with her friends of the same religion who were parents of students from other schools. The sub-teacher met those friends weekly for conversations on whatever they liked because they had the same religion. In our conversations in class, we found those friends influenced her teaching belief to some degree. Her friends pinpointed the necessity of allowing students to use technologies in schools. Also, the sub-teacher observed her sixth grade science class was quite boring for her students. Keeping her friends' comment in mind, the sub-teacher started thinking, "What would happen if I incorporate technology into my science class?" She then shared her thoughts with her two doctoral classmates and university professor in the class of Digital Learning and Teacher Professional Development. The professor therefore encouraged the sub-teacher and her two classmates to

conduct the collaborative action research linked to her inquiry. The rationale was as follows.

Action research beneficially affects the lives of both teachers and their students. Action research enables teachers to improve the learning experiences of their students when it links to a series of teachers' initiating inquiry engaging themselves in a process of self-reflection on their teaching practices (Baumfield et al. 2008; Stringer 2007). This is because critical self-reflection enables teachers to assess the effectiveness of their practice, focus on those aspects of their teaching that can be strengthened, and take steps to improve it (Danielson 2007). Baumfield et al. believe a more robust body of professional knowledge could be created and translated when teachers engage in more sustained, explicit processes of inquiry in their classrooms. This is because inquiry into teaching and learning can help teachers develop professional discourses about school learning. Such discourses not only transform their practice of teachers, but their understanding of that practice. This is a true benefit of teachers' critical self-reflection. Therefore, teacher inquiry through a process of action research could be an effective way to develop and innovate teaching and learning practice. It empowers and enables both teachers and their students to take control of their own teaching and learning (Stringer 2007). Conducting action research is a significant aspect of professional development for teachers because participation in a culture of inquiry is helpful for promoting teachers' professionalism (Danielson 2007). As Danielson advocates, the ability to reflect on teaching is the hallmark of a true professional. Thus, the project linked the sub-teacher's inquiry to action research as a vehicle for developing self-reflection in teaching.

Research Context

The research context was an elementary located at a disadvantaged school district in the central part of Taiwan. Most of the students came from middle-or lower-class families. There was only one e-classroom in the school, in which a teacher computer and projector were setup for teachers. The sub-teacher booked the e-classroom for her sixth grade science class early in the semester. The participants were students from a sixth grade science class taught by the sub-teacher (18 males and 14 females). At the very beginning of the semester, some of my colleagues came to me and said, "Many of the students were assigned to this class because of parental request. That was an under-the-table arrangement." In comparison with classes I substituted in the past, students of this class often asked questions related to the learning content. They were active but not out-of-control. According to my informal survey in the class, over 80% of the students in this class had a personal computer with an internet connection at home. However, I observed few students visit my blog at the early stage. Thus, I asked them for a reason in the class. Examples of student response are as follows: "My mom restricts the time of using computer because she is afraid that I would be indulgent in online games," or "I'm allowed to use computer only during holidays or when I get a good grade." Obviously, most of the parents restricted their time of using computer at home.

Research Group as the Critical Community

The sub-teacher, her two doctoral classmates and the university professor formed the research group for this collaborative action research. All three doctoral students attained their elementary-school-teacher's license before they got into a doctoral program. The sub-teacher had experience of short-term substitute teaching in different elementary schools for 2 years. As a short-term sub-teacher, she never had opportunities to teach the same class with a subject for a whole semester. This was the first time for her to teach the same class with the same subject for the whole school year. One of the two doctoral classmates was an administrator with 25 years teaching experience at an elementary school in another city. He used to be a mentor teacher of mathematics in the city he taught. The other classmate was about the same age as the sub-teacher. He was a full-time counselor of learning at one college and taught part-time at another college. Besides, he had 2 years sub-teaching experience at an elementary school. His master's thesis was on integrating technology into elementary science classes. The university professor was a teacher educator with a background in Educational Technology, having 5 years experience in elementary teaching.

According to Baumfield et al. (2008), the critical community provides teacher-researchers with a supportive arena where they feel confident to share their experiences and findings. At the same time, teacher-researchers expect to be asked tough questions by the critical community. Through skilled questioning and probing, the critical community engages teacher-researchers in serious, professional conversations which can help them become more accurate, analytical and insightful about their own practices (Danielson 2007). In other words, they can acquire the skill of reflection in practice through deep questioning in a supportive practice community. Therefore, the role of the community is dynamic from the initial idea, through the process of data collection, re-framing questions and analyzing findings. Interacting with the critical community, as a vehicle for professional development, is crucial to enriching the professional lives of teachers (Danielson 2007) and is important for teachers conducting action research (Baumfield et al. 2008).

Thus, the two doctoral classmates and the university professor played both the roles of the critical community and the collaborative researchers. The research group provided the sub-teacher with a very supportive environment in which she felt comfortable to share whatever she observed and ask questions. This was because there was a good rapport among them. The three of them had taken three seminar courses in a row from the professor on "Information Education", "Constructivism in Education", and "Digital Learning and Teacher Professional Development." Besides, the three doctoral students had experience of collaboration. They co-wrote a paper during the summer break and presented at a conference sponsored by the university in the following semester. Further, as a proponent of Constructivism, the professor had worked hard in generating conversations in all three courses. Therefore, the three of them were used to exchanging their thoughts in class. Also, the research group sometimes challenged the sub-teacher about what she did or thought. This was because the professor, based on her understanding of constructivism, believed challenging one's beliefs/values/perspectives was important for enhancing critical thinking of students. She often challenged students by asking questions in her classes. Therefore, the sub-teacher and her two classmates were gradually used to facing challenging questions in class.

Procedures

At the heart of action research are teachers with the intent to examine issues, helping them to more effectively and efficiently engage the complex world of teaching (Stringer 2007). Therefore, what is important is teachers' identifying questions and initiating changes in their classrooms that are of interest to them and designing an inquiry that is meaningful in their context (Baumfield et al. 2008). Thus, the inquiry of this collaborative research was proposed by the sub-teacher as how to engage the students of her sixth grade science class into active learning by incorporating technology and project-based learning. Constructivist principles underpinned the selection and implementation of learning activities. Further, the process of action research must underpin teachers' practice that is complementary to the model of plan-do-review (Baumfield et al. 2008). Stringer (2007) encapsulated the cycle of action research as a routine of observe-think-act. The cycle of this collaborative action research was illustrated as inquiry-act-observe-dialectic conversation-reflect. Each act as the teaching practice of the sub-teacher was a proposed solution to her inquiry emerging from her dialectic conversations with the critical community based on her observations in her classroom. Reflecting on the act taken formed new inquiry.

The research group met once a week in the Digital Learning and Teacher Professional Development class on campus. Often, the class began with questions raised by the sub-teacher based on what she did and observed in her science class. Then, the others gave her feedback based on what they heard during the conversations. The conversations continued through the class. Besides, there were asynchronous online interactions among them for exchanging thoughts, giving feedback to their writings, asking questions or asking for help in the teaching website of the professor. The sub-teacher and her two doctoral classmates also had synchronous online interaction through MSN when necessary. The following scenario gave an example of how the research group worked together as a research team as well as a critical community.

> Sub-Teacher: I like to distribute a questionnaire to the students at the end of their project. I like to know how they feel about this experience of learning.
> Professor: Good. And this can be the data for our action research. If possible, we can also help them to develop their meta-cognition ability if we ask the right questions.
> …
> Then, the sub-teacher posted her questionnaire on the website. The professor posted her feedback after reviewing the questionnaire. In the following week, all of them worked together revising the questionnaire in the class. They kept revising the questionnaire on the website for about three weeks. When the data of the questionnaire was collected, the professor modeled how to analyze and interpret the data in the class. The others completed the data analysis after the class.

Data Collection and Analysis

The data collected were as follows: the sub-teacher's observations in her 6th grade science class, the self-reported questionnaire distributed at the end of the student project activity, interviews with selected students, in-class and after-class teacher-student interactions, informal parent feedback, students' postings on the blog of the sub-teacher, and students' assignments (their group oral presentation with PPT, self- and peer- evaluation for their group project). The oral presentation of their project was videotaped. Triangulation was achieved through collecting and analyzing data from the different sources of evidence.

The questionnaire items included: (1) How did you find the information you needed? (2) How did you organize the information you got into your PowerPoint slides? (3) How did you learn to make a presentation with MS PowerPoint? (4) What problems did you encounter when creating the

PowerPoint slides? How did you solve them? (5) What is your evaluation of your group PPT presentation? (6) What are your evaluations of the other group PPT presentations? (7) What were the favorite parts of the processes in doing this project? Please give reasons. (8) What parts of the processes did you dislike in doing this project? Please give reasons. (9) How did you address your questions on the blog? (10) How did you locate suitable information to answer the questions posted on the blog?

Since the students' responses on the questionnaire were short and vague (ex: Good, I like it or I don't know), the sub-teacher conducted informal semi-structured interviews to some of the students during the breaks. For those who were active on blog, the sub-teacher was interested in their motivation and their learning. For example, the sub-teacher asked a student, "What motivated you to make a response on the blog? What did you learn from it?" For those who never showed up on the blog, the sub-teacher asked, "May I know the reason why you did not make any response or ask a question on the blog?" Regarding the PowerPoint project, the sub-teacher selected two types of students for the interviews: those who were active in their group discussions and those who always kept silent. The following are examples of questions the sub-teacher asked:

- What did you learn by doing this project?
- How did you prepare beforehand in order to be ready for the questions your peers might ask?
- How did you feel about the collaboration within your group?
- What were the pros-and-cons of your project presentation?

Descriptive statistical techniques were used to analyze quantitative questionnaire data. Qualitative data analysis techniques were used to analyze teacher observation, interviews, parents' feedback, students' assignments, student–teacher interactions, and students' postings on the blog. Each unit of qualitative data was assigned an identification code consisting of the following elements: type of data resource, student code, and date. For example, TSIAC-K-112309 referred to teacher-student interaction following class with student K on the date of Nov. 23rd, 2009; TPI-K-112309 represented the teacher-parent interaction with the parent of student K on the date of Nov. 23rd, 2009; TSIIC-K-112309 indicated teacher-student interaction in class with student K on the date of Nov. 23rd, 2009. Students' blog postings were classified into the following three categories: relevant to learning (such as asking questions, sharing information etc.), encouragement to the sub-teacher, and irrelevant postings (such as "Teacher! How old are you?") The analysis of teacher observations, parents' feedback, teacher-interactions, focused on the problems students encountered and their behaviors in the learning process. Regarding students' assignment, the analysis focused on how the students organized verbal and visual information (such as identified key concepts, use meaningful visuals etc.) The analysis of the interviews, questionnaires, assignments, and blog postings were also used to identify the students' abilities regarding information literacy and visual literacy. For example, "Copy-and-Paste" information in a PPT slide or blog posting was classified as a lack of information literacy.

Results, Discussions and Reflections

Promote Learning Motivation of Students

Students demonstrated their learning through their project presentation with MS PowerPoint. Their engagement in the project revealed their level of enthusiasm for learning. The sub-teacher observed many students engaged in learning activities, and assumed their responsibility for the assignment. They kept looking for new information, asking for the teacher's feedback and revised their PPT assignment. The parents' feedback supported this observation. The following were some evidences.

> Teacher, when will we present our project? We have found new information about pink dolphins. Can we revise it at home? (TSIAC-H-102709)
> Teacher, can you come to see my new assignment about the clouded leopard in Taiwan and give me some suggestions? I added some new information to it. (Student F, TSIAC-F-111309)
> My child and his classmates worked on their assignment about black bears in Taiwan together at our home last weekend. They were excited about what they were working on. (TPI-E-101309)

Additionally, some students who were too shy to ask questions or speak in class posted their questions on the sub-teacher's blog. For example, one student posted "May I ask one question? I wanted to know a long time ago, but I feared everyone would laugh at me…" (*Blog-K-102009*). Some shared new information obtained on the blog. The blog became a space for a further discussion in and beyond the class, which might deepen their understanding of the concepts in their textbook. The following excerpt showed how the discussion was going.

> Student E:Papaya trees, are they female or male? (Blog?)
> Teacher: Based on the textbook, female, male or hermaphrodite. (in class-112409)
> Student I: If we insert a rusty nail into papaya trees, the sex of the papaya trees may be changed. (Blog-I-112409)

The data of student interviews showed some valued the use of the blog for their learning. What they liked about the blog was the opportunity for peer learning by reading others' postings. Also, they enjoyed visiting digital museum through the links on the blog. All of these were new to them. Clearly, the blog became a space for extended learning beyond the class.

> I especially like the discussions on the blog. I could read others' responses and learned more about science. (Interview-K-120109)
> I like the links on the blog. This is because I enjoyed reading information about reptiles in the Digital Museum Zoology of National Taiwan University. (Interview-F-120409)

The students were very excited to see the group presentations of each other. It was a completely new experience for the students. Many of them enjoyed the work on their projects and were very proud of their final presentations. The new experience of learning promoted the motivation and engagement of the students for finding value and joy for learning.

The results showed flexibility in how to learn empowered the students to take responsibility for their own learning and develop sufficient confidence and appreciation of new knowledge. The enthusiasm and high interest level were indicators of the positive impact on student learning in the affective domain. Corresponding to McPherson's study (2009), given alternative ways to demonstrate what they had learned, students were eager to begin their projects and were enthusiastic about learning. For some students, the project engaged them in learning experiences in ways they learned best that might prepare them to become successful life-long learners.

Effective integration of technologies requires simultaneous innovations in pedagogy and assessment (Dede 1998). In this study, the shift from lecture-based to constructivist pedagogy is one of the key components. According to Wilson (1996), a constructivism classroom is 'a place where learners may work together and support each other as they use a variety of tools and information resources in their guided pursuits of learning goals and problem-solving activities' (p. 5). The use of a blog enabled the sub-teacher to create a learning environment for students to share ideas among peers, facilitating their cooperation on the PPT assignment. Most importantly, the role of the teacher changed significantly. The sub-teacher acted as a guide for student exploration through their group project rather than solely being a dispenser of knowledge. The students were responsible for locating information and organizing it into a MS PowerPoint presentation.

The results showed some students spontaneously revised their PPT presentation. Barron et al. (1998) found students took advantage of the opportunity to revise their work with enthusiasm when they learned in a PBL classroom. The teachers of their study were very surprised about students' redoing their work without complaints. This was because students in traditional classrooms did not normally revise their assignment. The finding of this study is consistent with the study of Barron et al. (1998). Further, some students enjoyed the use of the blog to extend their learning. This finding corresponds to Churchill's (2009) that the use of a blog could facilitate student learning. The use of a blog enables teachers to create an environment where students' needs and opinions are recognized and addressed. All of these enabled the students to experience how to learn with technology in a constructivist environment by being an active agent in their learning.

Lack of Information Literacy as a Serious Problem

Eisenberg (2008) suggested PowerPoint as a synthesis tool for teaching information literacy. However, there was little synthesis, imagination, and creativity applied in the student writing for their PPT presentation though the students of this study were motivated in creating PPT slides. In the questionnaire, 42% of the students reported being able to find key concepts, but the analysis of their PPT content revealed most of their PPT content was not well-organized. This result corresponds to Probert's study (2009) that students lack note-taking and skimming skills. Further content analysis of student PPT revealed the students simply copied and pasted rather than synthesizing the internet information. The culture of "copy and paste" among students signified the need for discussions on copyright and plagiarism. The problem of students' "copy-and-paste" behaviors also occurred in their blog interaction. Most of the students cut and pasted internet information or retyped information from books in their postings. None provided appropriate citations.

The culture of "copy-and-paste" established among the students in this study was not unique. Previous literature had revealed the concern of the "copy-and-paste" phenomenon (Auer and Krupar 2001; Ellery 2008; Krumsvik 2006). The students of this study knew nothing about the ethical use of information. According to AASL and AECT (1998), an information-literate student respects intellectual property rights. Unfortunately, the students did not know their copy-and-paste behaviors violated copyright/intellectual property rights and they might be accused of plagiarism. The easy process of copy-and-paste on web resources might deprive students of reading thoughtfully and obtaining better understanding through paraphrasing processes (Auer and Krupar 2001; Ellery 2008). The discussed literature points out the culture of copy-and-paste will lead students to the jeopardy of plagiarism because

they are not equipped with appropriate paraphrasing skills in order to present unplagiarised material.

Besides, the data of class discussion showed most students used key words when searching for information. However, they lacked discernment and discrimination skills in their use of internet information; that is, they did not evaluate the information they retrieved from the Web. Most of the students never questioned the authenticity, dependability, and authority of the information resources. They simply clicked the first and second URL in the list of search results and used it for their project without comparing the selected information. Neither did they think of verifying the information. The following excerpt from a class discussion on Dec. 11th, 2009 was an example.

> Teacher: How did you search for information?
> Student D, E, F (simultaneously): keywords.
> Teacher: If there was a huge amount of information, what would you do?
> Student J: I always chose the first and second in the list.

Only one student questioned the authority of information he found. Student C asked, "Is all of the information on the internet correct? I was so confused because there were different messages about the same topic I was looking for." (*TSIIC-C-111309*).

This result supports Walraven et al. (2008) conclusion that students of all ages encounter problems with judging search results, and judging the source and information.

The above discussions reveal the lack of information literacy skills of the students. This finding highlighted the need of teachers' scaffolding support to foster students' information literacy as previous researchers advocated (Almås and Krumsvik 2007; Krumsvik 2006; Probert 2009; Walraven et al. 2008). Given the huge amount of information available to students online, Probert (2009) emphasizes the importance for students to learn, evaluate and assess information effectively, and to take useful notes. Thus, teachers are responsible for modeling information-searching skills for their students. They also need to teach their students with skills of note-taking, and skimming. Most importantly, they have to teach their students the ethical use of information. In short, PowerPoint can be a synthesis tool only if students learn how to evaluation information beforehand.

Students Need to Improve Visual Literacy

The self-report questionnaire data showed 62% of the students learned how to make PPT slides in their computer class when they were in 5th grade. This project gave the students an opportunity to demonstrate their mastery of skills in using PowerPoint. The students had few technical problems. The result showed they were able to translate the technology skills into their project. However, the analysis of visual information displayed many of their PPT slides lacked visual appeal. Three-fourths of their PPT slides had the problem of texts with color similar to the background. Examining their peer-and self-assessment, none recognized this as a problem. Besides, the more pictures that were used, the higher the score they assigned to their peer assessment. In other words, the students lacked knowledge of the appropriate use of colors and the selection of applicable multimedia based on the intended message and social context. They knew little about visuals not necessarily increasing the quality of their PPT presentation. These results indicate their lack of visual literacy.

The finding echoes the assertion by the advocates of visual literacy that visual literacy is the missing piece in current education (Metros 2008; Pettersson 2009; Sosa 2009; Yeh and Cheng 2010). Visuals are an integral part of meaning making (Dastani 2002). Developing visual literacy is important for students living in a visual society where visual information is ubiquitous and is easily created with current digital technologies. Students are exposed to visual information in their daily social practices. Visual literacy is a social practice in which the use of visuals is mediated by the social context in which they appear (Sosa 2009). The abilities to understand, analyze, interpret, and create visual information are vital for students (Metros 2008; Pettersson 2009; Sosa 2009; Yeh and Cheng 2010). They need both the skills and abilities to generate meaningful visuals to communicate with others. They also need to learn how to make ethical judgments about the accuracy, validity, and worth of visual information. Thus, teachers must prepare students to be successful consumers and creators of new media by teaching them how to analyze, interpret, compose, and create and visual information (Metros 2008). The finding of this study confirms the need for visual literacy as an important instructional component when students are encouraged to use technology to express what they learned.

Conclusions

Incorporating technology into project-based learning enables the students to experience how to learn with technology as an active agent in their learning. The autonomy over what to learn and how to demonstrate what they learned motivates students in science learning. However, the students under this study lacked the skills of information evaluation, note-taking and information organization. Neither were they aware of the issue of intellectual property. Also, the students lacked visual literacy, so they did not use visuals in a meaningful way for their PPT

slides. All these findings imply the importance of teaching students about information literacy and visual literacy when introducing information technology into the classroom. Additionally, teachers should teach information literacy by integrating it into an inquiry project for a subject learning instead of teaching it separately. Further research should focus on how to break the culture of "copy-and-paste" by teaching the skills of note-taking and synthesis through inquiry projects for science learning. Also, this study reveals that the collaboration action research conducted by the sub-teacher, her doctoral classmate and university course instructor is an effective professional development for enhancing classroom technology integration of the sub-teacher. Therefore, further research on teacher professional development should focus on using collaboration action research as a framework for redesigning graduate courses for science teachers in order to enhance classroom technology integration.

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