

The Development of Pre-Service Science Teachers' Professional Knowledge in utilizing ICT to support Professional Lives

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Received 13 February 2008; accepted 23 August 2008

In the rapidly developing digital world, technology is and will be a force in workplaces, communities, and everyday lives in the 21st century. Information and Communication Technology (ICT) including computer hardware/software, networking and other technologies such as audio, video, and other multimedia tools became learning tools for students in the 21st century. ICT also changed the nature of the teachers' work and the way they relate to other teachers in their professional lives. The researcher designed and implemented a course to enhance 18 pre-service science teachers' professional knowledge, which knowledge of instructional media and technology is one of the important domains. Technology was used as a tool for enhancing the development of professional knowledge in a seminar organizing activity in which students designed instructional movies and participated in online discussion activities. Data from questionnaires, classroom observation, journals, online discussion boards, and pre-service science teachers' artifacts were analyzed by the constant comparative method. The results revealed that most of the pre-service science teachers felt more comfortable using software and hardware, were willing to learn, improve their creativity, participate in group collaboration, and felt free asking questions and reflecting on their ideas on discussion boards. The results show that pre-service science teachers develop their professional knowledge when they are engaged in embedding ICT in subject teaching activities.

Keywords: ICT, Pre-service Science Teacher, Professional Knowledge, Teacher Education

INTRODUCTION

Over several decades, many learning resources such as educational documents and instructional media have

been produced in electronic formats. This is causing the learning process to change from paper resources to electronic resources. An essential tool used by humans to acquire knowledge in the 21st century is Information and Communication Technology (ICT) and ICT literacy is critical for today's students (Partnership for 21st century skills, 2007). ICT literacy was broadly defined as a combination of computer skills and knowledge of how to use information in new formats made possible by computers (Sellen, 2002).

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When workplaces, communities, and everyday life require skills for the 21st century, students need to be trained for it. 21st century skills include reading, writing, computing, and how to use essential tools such as computer hardware/software, networking, and other technologies such as audio, video, and multimedia tools (Partnership for 21st century skills, 2007). Teachers are an important aspect of ICT skill acquisition. But teachers cannot prepare students for 21st century context unless they understand, possess, and use those skills themselves (Laferriere et al., 2006).

The domains within teacher professional knowledge as defined in the professional literature include:

- ♦ knowledge of educational context,
- ♦ general pedagogical knowledge,
- ♦ subject matter knowledge, pedagogical content knowledge (Elbaz, 1981; Nazri, 1990; Vonk, 1995; Collinson, 1996; NSTA, 2003; and Leou & Liu, 2004),
- ♦ knowledge of instructional media and technology,
- ♦ knowledge of educational philosophy, and
- ♦ knowledge of research on best practices (Nazri, 1990; NSTA, 2003; and Leou & Liu, 2004).

Knowledge of instructional media and technology has become one of most essential domains in this century.

Teacher professional knowledge is not only related to knowledge and teaching practice, but also other professional roles in and outside the classroom including tutoring students, participating in school activities and projects, interacting with members of the community, and working in professional groups. As ICT changes the environment in which teachers work and the way they relate to other teachers, it has an important impact on the nature of the teachers' profession (Pedro da Ponte, et al., 2002). In the workplace, teachers have been encouraged to use technology in their subject teaching, both at in service and pre-service levels (Mishra and Koehler, 2006; Kay 2006, Galanouli, et al., 2004) including teaching-with-technology, designing software and creating of technologically based tools to support their professional work (Kerr, 1989).

So, now in teacher education, to prepare professional teachers, a web-based system has been suggested as a tool for revitalizing and reforming teacher education courses (Shi, et al., 2004, Barnett, 2006; Ikpeze, 2007; Kay, 2006; Laferriere, et al., 2006; Pedro da Ponte, et al., 2002; and Rodrigues, et al., 2003). Multiple strategies have been used such as web page design (Pedro da Ponte, et al., 2002 and Shi, et al., 2004), digital photography and PowerPoint presentations (Wursta, et al., 2004), technology-based search activities (Bahr, et al., 2004, Shi, et al., 2004, Schrader, et al., 2003), online discussion (Laferriere et al., 2006; Kay, 2006; and

Ikpeze, 2007) and movie production (Mishra and Koehler, 2006).

Among these, technology-based search activities, in which teachers use the web to identify resources that support their teaching, helps teachers use technology as a tool in the classroom to improve instruction. Online discussion provides opportunities for teachers to reflect, collaborate, and share ideas with other members in the group. This activity can be used effectively to enhance development of teachers' professional knowledge (Ikpeze, 2007). Producing a video or movie is another strategy which is based on a "learning technology by design" approach (Mishra and Koehler, 2006) and helps learners to become practitioners who construct artifacts, and change from passive learners to learners who take control of their learning (Mishra and Koehler, 2006; Condie and Livingston, 2007).

Recently, there have been many updated software tools that can be used to support these activities through a web-based system. Teachers must simply select the ones that meet their specific content or pedagogical goals (Mishra and Koehler, 2006).

Objective of the study

This study is one part of the development of a course to enhance pre-service science teachers' professional knowledge. This part aimed to determine in what way does the course enhance pre-service science teachers' knowledge of instructional media and technology, and other related domains of professional knowledge during the course?

MATERIALS AND METHODS

Research Design

To answer the question of the study, a qualitative interpretive study was employed as the research design. From this design, the researcher inferred the development of pre-service science teachers' professional knowledge in terms of instructional media and technology use through activities related to designing instructional movies, and online discussion activities in the course.

Research Participants

The participants of this study were a group of eighteen 4th year pre-service science teachers who were enrolled in a 15-week capstone course in the first semester of the 2006 academic year in the Faculty of Education at an institution in Central Thailand.

Research intervention: a capstone course method course

The researcher acted as the course instructor in this study. Two hours a week, for fifteen weeks, the capstone course aimed to enhance pre-service science teachers' professional knowledge by using the seminar process.

There were many course activities used to enhance each domain of professional knowledge. Instructional media and technology was an organizing aspect of the seminar through online discussion and instructional movie production activities.

The seminar required groups of pre-service science teachers to search for information from online and other sources and to be responsible for being a leader for a weekly seminar. Each group, consisting of two to three people, planned, searched, concluded, and presented information in the form of a seminar discussion activity. This activity aimed to enhance pre-service science teachers' abilities in utilizing ICT as a tool to search for information.

The online discussion activity was introduced and was used from the first week of the course. The researcher constructed a seminar website as a main page, through which members were able to link to the online discussion board. The aim of the online discussion board was to provide opportunities for pre-service teachers' reflections, and to act as another learning resource which class members could access any time and from anywhere.

Windows Movie Maker is a basic program provided on the Windows XP operating system. The researcher selected this program because it is user friendly and appropriate for the classroom context. An example of a video case produced by Windows Movie Maker was first introduced in the 9th week for a discussion activity, and a document about the program was distributed to every pre-service science teacher to study both on paper and via electronic formats.

After that, in the 10th week, a volunteer group of students, who were trained in using the Windows Movie Maker program from the researcher, acted as an instructor group. They organized and facilitated the other pre-service science teachers in a movie production activity. A hundred and twenty minute class was divided into two sections: the first 60 minutes made up the instructional part, and the last 60 minutes made up the practical implementation. In the practical part, each group selected a topic of science, practiced movie production, and presented their instructional movies at the end of class.

At the end of fifteen weeks, one of the seminar course requirements was to produce a short segment of instruction using instructional media. Each group of pre-service science teachers selected topics, methods,

and designed instructional media based on their selected science topic.

Data Collection and Analysis

To answer the research question, information acquired from classroom observation, questionnaires, online discussion boards, pre-service science teachers' weekly journals and artifacts was collected and analyzed by using the constant comparative method (Bogdan and Biklen, 2003).

A rating scale questionnaire was designed to capture the readiness of pre-service science teachers in each domain of professional knowledge. One part of the questionnaire was aimed to capture knowledge of instructional media and technology. In this section, there were three items about levels of readiness including producing instructional media, selecting instructional media for science teaching, and utilizing ICT. The questionnaires were completed by participants before and after the course. The scale ranged from low to medium, and medium to high levels of readiness.

In addition, the researcher collected data from online discussion boards and pre-service science teachers' weekly journals and artifacts. Data from every source were read and coded. The classifications emerged from incidents that were written, compared and analyzed to generate the core categories. Finally, all findings were compared and conclusions were drawn to answer the research question.

RESULTS

To present the results, the researcher first report what happened in each activity, and summarizes what knowledge of instructional media and technology was enhanced from every activity in the course. The results from questionnaires before and after the course are reported at the end of this section.

Seminar Organizing Activities

There were seven groups of pre-service science teachers that were responsible for each weekly seminar topic. Topics included lesson plans, cooperative learning, inquiry, lectures/discussion/demonstration, student prior knowledge/assessment, instructional media and technology, classroom management, and science process skills. Each group sent their group seminar proposal to the instructor one week before the seminar started, and at the end of the seminar every group wrote reflections on the seminar organizing activity in their weekly journal.

Results from reflections of the group revealed that ICT knowledge and skills were gained from this activity.

Some groups talked about conducting internet searches in their reflection including:

“After we talked about the information that we needed for the seminar, everybody in my group started searching from internet resources and books. We brought the information to discuss and selected reliable sources” (group 1)

“We searched information from a variety of sources; being an instructor makes me read and search more critically for more information from internet resources to get good information from numerous and reliable sources for what we teach” (group 2)

“We started searching for information from a variety of sources 3 weeks before our group started. At that time I just read topics and printed out a bunch of information without going into the details. I learned it did not work....I should be more critical in searching, so I feel like I haven't wasted my time” (group 3)

“Our group spent most of the time planning and searching for information; we read information from the book first and started looking though the internet which has a variety of sources. We have to critically read, group, and select all information that everybody is able to understand” (group 5)

Some members of each group gained skills in operating software/hardware such as making PowerPoint Presentations:

“I was responsible for making the PowerPoint

presentation, so that enriched my skills in using that program” (group 1)

“I'm the one who made PowerPoint our presentation; this made me skillful and familiar with computers” (group 3)

One group was forced to communicate and plan via e-mail and online conference tools due to a school break.

“Because our seminar preparation is during the school break, we were forced to use email and instant messenger to communicate like teleconferences” (group 4)

From the seminar organizing activity, ICT knowledge and skills of pre-service science teachers were enriched including conducting internet searches, operating software/hardware, and e-mailing and online conference.

Online Discussion Activities in the Course

At the beginning, after the online discussion board was introduced to the class, there was only one pre-service science teacher that posted a question about formative assessment, and none of the others joined the discussion. Therefore, the researcher brought the topic that was posted to the next class and reminded the other class members of the importance of reflection and discussion, and the flow of activity started. The participation of pre-service science teachers and the researcher in online discussion activity is presented in Table 1.

Table 1. Participation of Pre-Service Science Teachers and the Researcher in Online Discussion Activity

1	Topics of Seminar	Participation of	
		Pre-service Science Teachers	Researcher
1	Introduction		- introduced activity
2-4	Student teaching	- discussed about formative assessment.	- suggested learning resources
	Student teaching	- expressed personal feelings.	- encouraged class members' participation.
	lesson plans		- comforted class member
5-7	nature of science	- uploaded pictures.	- encouraged class members
	cooperative learning	- discussed student teaching, lesson plans.	- suggested resources
	inquiry	- express personal feelings.	- comforted class members
		- reflected on seminar topics.	
8-10	lectures/discussion/ demonstration	- uploaded pictures.	- encouraged class members
	student prior knowledge/ assessment	- made a link to current news.	
	instructional media and technology		
11-12	classroom management	- discussed instructional media, classroom management.	- discussed topics
		- uploaded pictures.	- encouraged class members
		- express personal feelings.	- comforted class members
	science process skills	- reflected on seminar topics.	
13-15	Micro teaching	- expressed personal feelings.	- comforted class member

After the first week, more class members joined the online discussion by asking and answering questions, asking for and suggesting learning resources, posting some photos or links about current scientific news, and also reflecting their feelings about weekly seminar activities. Discussed topics included formative assessment in weeks 2-4, student teaching and lesson plans in weeks 5-7, and instructional media in weeks 11-12. At the end of the course, micro teaching took place. During this time, pre-service science teachers only expressed their personal feelings. As seen in Table 1 above, the researcher engaged in the online discussion activity not only as a participant in the discussion, but also as an encourager for class members' participation along the course.

However, there were many class members who rarely or never participated in online discussion. The reasons behind this were represented in their weekly journals. The reasons were based on personal characteristics and student access to computers. Some pre-service science teachers were not computer literate, and some of them didn't have a personal computer at home or stayed in dormitories where computer access was limited.

The Designing Instructional Movies Activity

From classroom observation and weekly journals, the researcher found out that out of 18 pre-service science teachers, only three knew about the Windows Movie Maker Program. One student had never used the program, and two rarely used the program. None of them thought about using this program to produce instructional media for science teaching.

In this activity, the researcher provided 3 computers, which contained pictures and video resources for class members, and also provided a microphone, speakers, and a webcam for each computer. The instructors, who were a volunteer group of pre-service science teachers, divided other class members into 3 groups.

At the beginning of a hundred and twenty minute class period, (60 minutes of instruction and another 60 minutes of practicing) the instructor group introduced the program and demonstrated how to use it. The first step was importing/capturing video files and putting video clips on a timeline. The second step was about adding effects, transitions or tiles, and the last step involved producing/saving a movie file. In each step, an instructor provided chances for class members to practice with the computer and other instruments.

In the practical section, each group started the process of making an instructional movie production by using Windows Movie Maker. There were one or two students serving as assistants from the instructor group. Groups of pre-service science teachers selected a science topic, planned, and practiced producing

instructional movies. In the planning process, every member discussed choosing an appropriate scientific topic within the group. After that, some groups started writing scripts, while the others started searching for pictures and videos. At the end of the class, each group presented a movie, and described how to use it in the classroom. Finally, the remaining groups provided feedback to the presentation group. The researcher engaged as a participation observer during the class. Pre-service science teachers spent time on discussing, debating, filming, editing and revising their projects. There were conversations, practices, laughs, and group process in steps of planning, producing, and presenting the movie.

At the end of the course, out of the 7 groups of pre-service science teachers, 3 groups produced instructional media by using computers to achieve a course requirement. Two of them created instructional media videos and the other one produced an online flip album. Those instructional media were on the topics of parts of trees (grade 7), animal life (grade 7), and earth atmosphere (grade 8).

Each artifact, instructional media CD and manual was analyzed and coded according to the domain of the teacher professional knowledge that was enhanced. The results are presented in Table 2.

The first group produced instructional media by using the Windows Movie Maker program for grade 7 students in sub-strand 1: Living Things and Living Processes. Level standards were identified in the instructional CD manual as "Investigate, search for information, discuss and explain structures and functions of various systems in living things (plant, animal, and man), interrelationship of functions and apply knowledge acquired". Correct and appropriate content was presented in the file about structures and functions of plants. They recommended using this file as a supplemental resource that represented real structures of trees. Knowledge of instructional media and technology used in producing the file included filming, searching, importing pictures and video files, operating software/hardware, and producing movies.

The second group produced instructional media by using the Windows Movie Maker program for grade 7 students in sub-strand 2: Life and the Environment. Level standards were identified in the instructional CD manual as "Explore and analyze status of various local ecosystems, explain relationships between components within the eco-system, energy transfer, cycles of substances and change of population size". Correct and appropriate content was presented in the file about relationships of animal life within the eco-system. They recommended using this file as instructional media during the introduction of science a lesson for engaging student interests and inquiring about student prior knowledge. Knowledge of instructional media and

Table 2. Professional knowledge of Pre-Service Science Teachers that was enhanced in producing instructional media videos

Professional knowledge	Program (Science Topics Grade	Windows Movie Maker: TV Program (Trees) 7	Windows Movie Maker : Music Video (Animal life) 7	Flip Album: (Earth Atmosphere) 8
knowledge of educational context		Sub-strand1: Living Things and Living Process <u>Level standard</u> Investigate, search for information, discuss and explain structures and functions of various systems in living things (plant, animal, and man), interrelationship of functions and apply knowledge acquired.	Sub-stand 2: Life and the environment <u>Level standard</u> Explore and analyze status of various local ecosystems, explain relationships between components within the eco-system, energy transfer, cycles of substances and change of population size.	Sub-strand 6: Processes that shape the earth <u>Level Standard</u> Search for information, discuss, meteorological phenomena, interpret weather forecasts, explain meteorological changes on living and environment.
subject matter knowledge		- structures and functions of plant	- relationship of animal life within eco-system	- components and stratification of the atmosphere - factors affecting temperature change on earth
general pedagogical knowledge,		- used as a supplemental resource with real structures of trees.	- used as instructional media at introduction of the lesson.	- used as an additional resource with pictures and information about stratification of the atmosphere, ozone layer and greenhouse effect situation.
knowledge of instructional media and technology		- Filming - Searching, importing for pictures and videos files. - operating software/hardware - producing movie	- Searching, importing for pictures, videos and audio files. - operating software/hardware - producing movie	- Searching, importing for pictures files. - operating software/hardware - conducting internet searches

technology used in producing the file including searching, importing pictures, videos and audio files, operating software/hardware and producing movies, and conducting internet searches.

The last group produced instructional media by using the Flip Album program for grade 8 students in Sub-strand 6: Processes that Shape the Earth. Level standards were identified in the instructional CD manual as "Search for information, discuss, meteorological phenomena, interpret weather forecast, explain meteorological changes on living and environment." Correct and appropriate content was presented in the album about components and stratification of the atmosphere, and followed with factors affecting temperature change on earth. They recommended using this file as an additional resource that provided pictures and information about stratification of the atmosphere,

ozone layer, and greenhouse effect situation. Knowledge of instructional media and technology used in producing the file included searching, importing pictures and files, operating software/hardware, producing movies, and conducting internet searches.

The Development of Knowledge of Instructional Media and Technology of Pre-Service Science Teachers

The results from activities including seminar presentations, the online discussion board, and the movie production practice were coded, compared, and generated into categories of knowledge of instructional media and technology that were enhanced during the course. The categories are presented in Table 3.

Table 3. Knowledge of instructional media and technology that was enhanced in a capstone course

Knowledge of Instructional Media and Technology	Activities used in course		
	Seminar organizing	Online discussion board	Windows Movie Maker
files formats		/	/
uploading and downloading		/	
operating software/hardware	/	/	/
create hyperlinks		/	
conducting internet searches	/	/	/
produce movie			/
Emailing and teleconferences	/		

/ represents an existence of knowledge of instructional media and technology in each activity.

As seen in Table 3, pre-service science teachers' knowledge of instructional media and technology was enhanced during the course in the areas of files formats, uploading and downloading files, operating software and hardware, create hyperlinks, conducting internet searches, the process of movie production and emailing and teleconferences.

The following quotes represent examples of pre-service science teachers' reflections in weekly journals that were coded in the category called file formats:

"There are many formats of pictures files, these can be .jpg, .gif. If we want animated pictures, we should search for pictures with a .gif"

"The movie files that I know are those that have .wmv, .mov, .mpeg"

In the category of operating software/hardware, pre-service science teachers expressed that

"Now, I know how to use Windows Movie Maker program in producing a movie."

"I know how to use webcam to capture still pictures and movies."

"I am getting familiar with using the computer and some programs that I had never used before."

In the online discussion board activity, there were many class members uploading pictures and downloading files from online learning resources. Some of them also made hyperlinks to share knowledge with friends.

Moreover, pre-service science teachers' artifacts showed an integration of their knowledge which included scientific, pedagogical, and technological knowledge in the process of instructional movie production.

The integration of knowledge is presented in Figure 1 using a model of Pedagogical Technological Content Knowledge (TPCK) that was proposed by Mishra and Koehler (2006). Content knowledge is coded as C, pedagogical knowledge as a P and technology as a T.

In designing instructional media videos, pre-service science teachers integrated knowledge of science in specific content areas (content knowledge: CK), pedagogical knowledge (pedagogical knowledge: PK) or methods of teaching and learning into the idea of knowing what teaching approaches fit the content (pedagogical content knowledge: PCK).

When pre-service science teachers had basic knowledge and skills in using technology (TK) for producing instructional movies such as operating software and hardware, searching and importing pictures or video files and filming, they selected an appropriate scientific concept that can be changed by the technology. This referred to an idea of technological content knowledge (TCK).

Pre-service science teachers presented technological pedagogical knowledge (TPK) in applying pedagogical strategies for use of technology. The interweaving of all domains of knowledge including content, pedagogy, and technology was presented in the movie production activity including: using appropriate technology to produce instructional movies as a supplemental resource or as an additional resource to present specific science concepts.

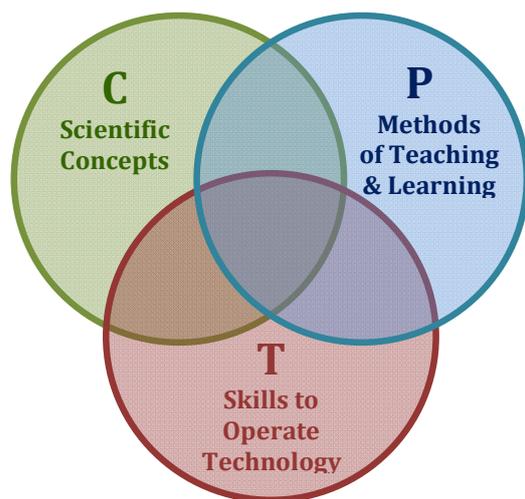


Figure 1. An Integration of Teachers' Professional Knowledge including Scientific, Pedagogical, and Technological Knowledge in the Process of Instructional Movie Production
(Adapted from Mishra and Koehler, 2006)

Table 4. The readiness in knowledge of instructional media and technology of pre-service science teachers before and after participating in a capstone course

Item	Knowledge of instructional media and technology	The level of readiness (%)			
			Low	Medium	High
1.	producing instructional media	Before	22.22	72.22	5.56
		After	0	77.78	22.22
2.	selecting instructional media for science teaching	Before	0	83.33	16.67
		After	0	77.78	22.22
3.	utilizing ICT	Before	11.10	83.34	5.56
		After	0	50.00	50.00

Upper row of each item presented percent of readiness before participating in a capstone course.

Lower row of each item presented percent of readiness after participating in a capstone course.

In addition, there were some important characteristics that were enhanced by these activities, such as feeling more comfortable using software and hardware, feeling free in asking and reflecting on ideas, using creativity and artistic abilities, working in collaboration, being willing to learn, and an eager desire to stay up-to-date. Some pre-service science teachers expressed their opinions on benefits and limitations of online discussion boards, and the Windows Movie Maker Program. The online discussion board's beneficial characteristics included being able to access the dialogue at any time and from anywhere. Limitations of this tool included: topics weren't instantly responded to after being posted and computers were not available to everyone. The Windows Movie Maker Program's beneficial characteristics were user friendliness, and accessibility with the Windows XP program already installed on computers. Limitations presented by the group included: the fact that the program does not support a variety of video file formats, and also a limitation of available tools such as computers, webcams and microphones.

Questionnaires: The Readiness of Pre-Service Science Teachers to use Knowledge of Instructional Media and Technology

Results from the questionnaire (Table 4) showed the percentages of responses given by pre-service science teachers about the readiness in knowledge of instructional media and technology before and after participating in a capstone course.

Table 4 shows responses from pre-service science teachers before and after the course. The general trend is toward increased readiness in each area. There are increasing percentages of high level of readiness in all three categories. These changes show that pre-service science teachers felt more ready in their knowledge of instructional media and technology including producing instructional media, selecting instructional media for science teaching, and utilizing ICT after participating in a capstone course.

DISCUSSION

Through the seminar activity, pre-service science teachers utilized their knowledge of instructional media and technology including conducting internet searches, operating software/hardware, and emailing and online conferencing. Their reflections revealed that engaging in technology-based search and presentation activities helped them develop skills related to searching the internet, and utilizing PowerPoint presentations. These are thought to be basic technology skills teachers can use to help support their careers (Dawson, 2008). This finding is comparable to findings of Bahr, et al. (2004), who found that implementing long-term technology in teacher education provided helpful insight into preparing teachers to use technology in the classroom to support instruction (Bahr, et al., 2004).

In the beginning of the online discussion activities, conversations between participants were not flowing well. The researcher, who engaged as a course instructor, encouraged members' participation by reminding them of their course responsibilities. This was based on suggestions from Mishra and Koehler (2006) and Ikpeze (2007). Mishra and Koehler (2006) recommended that the main role of the instructor was facilitating discussion and being a problem solving expert. To accomplish this, the instructor should read postings, synthesize the discussion and provide responses to the class members (Ikpeze, 2007). As the researcher in this study used techniques of this type, online discussion among student improved. These results support the use this recommendation.

The results also showed that although the instructor's role is important, individual student personal characteristics and computer availability can also greatly affect discussion activity outcome. When a topic or a question was posted with no one responding, it was determined that this can be a cause of non-flowing activity. Ikpeze (2007) said interaction stimulates more interaction. That is, discussions that begin to flow sometimes take on a life of their own and will be sustained as members keep responding to one

another. In addition, a finding similar to that described by Parkinson (1998) was evident in this study as a significant number of pre-service science teachers did not use ICT in teaching because of their personal feelings and insufficient machines.

Results showed several important characteristics of pre-service science teachers that were enhanced in this activity. These included feeling more comfortable using software and hardware, feeling free in asking and answering questions, and being comfortable in critical reflection. The comfort level in using computers of pre-service science teachers was similar to the findings of Pedro da Ponte, et al. (2002)'s study on mathematic teachers. He was concerned with an anxiety regarding technology as a significant issue for pre-service mathematic teachers' education. He found the pre-service mathematic teachers gained confidence in using computers when participating in the production of web pages designs.

The freedom in asking and answering questions, and critical reflections were associated with issues of student empowerment and active learning proposed by Ikpeze (2007). He said when teachers participated in online discussion, they were able to reflect and exchange ideas among themselves. This was an important method to help them change from being passive to active learners (Ikpeze, 2007).

One main advantage of the online discussion board proposed for pre-service science teachers in the course was opportunity to choose when and where to join an online discussion. This was in line with Rae and Kay Livingston's (2007) suggestions. Their results suggested that e-learning opportunities allowed the students to take control of their own learning. They were able to choose what, when, and where to learn (Rae and Kay Livingston, 2007).

In this study it was found that when pre-service science teachers participate in educational technology activities, they developed not only their professional knowledge of instructional media and technology, but also they learned to integrate other domains of professional knowledge such as scientific and pedagogical knowledge. Their learning process and artifacts showed that they learned how to use technological tools in their subject teaching. This result was aligned with the findings of Mishra and Koehler (2006) and Rodrigues et al. (2003). Mishra and Koehler's (2006) determined that teachers develop knowledge of content, pedagogy, and technology together when they participated in authentic design-based activities. Moreover, using ICT as a tool for science teaching also encouraged teachers' pedagogical content knowledge (Rodrigues et al., 2003). While participating in designing technology based activities, teachers not only learned technology, but how to think deeply about and apply their professional knowledge.

The development of pre-service science teachers' professional knowledge in utilizing ICT to support their professional lives emerged during pre-service science teachers' participation in the course. The teachers' readiness to use knowledge of instructional media and technology was presented in a table which showed that pre-service science teachers were more confident in using technology supported science teaching after the course. These outcomes were comparable with Galanouli, et al. (2004) and Wursta (2004)'s findings, who discovered that utilizing digital photography for modeling best practices (Wursta, 2004), and participated pre-service science teachers in ICT training program (Galanouli, et al., 2004) increased student teachers' pride and confidence in using computers (Galanouli, et al., 2004 and Wursta, 2004).

CONCLUSION

From the results, it can be concluded that this course enhanced pre-service science teachers' professional knowledge in the domain of knowledge of instructional media and technology including the areas of files formats, uploading and downloading files, operating software and hardware, create hyperlinks, conducting internet searches, the process of movie production and emailing and teleconferences. Moreover, pre-service science teachers presented an integration of other related domains of the professional knowledge such as content and pedagogical knowledge with the knowledge of instructional media and technology in the designing of movie activities. The course helped pre-service science teachers develop helpful characteristics and confidence in utilizing technology to support their teaching profession.

Implications and recommendations

There following are recommendations from the study:

1. Teacher education faculty should consider integrating knowledge of instructional media and technology into teacher education courses to prepare pre-service science teachers. They should provide practical experiences for them to integrate this domain with other domains of teacher knowledge into the area of their teaching.

2. To use online discussion as a tool, an instructor should be concerned about the flow of discussion. Every participant should be informed about the importance of responding or providing feedback to every posted question. Moreover, the instructor should consistently visit the online discussion board; provide feedback to ideas, questions or feelings; and also encourage class member participation.

3. To embed ICT in teacher education, a course designer or an instructor should be concerned about the technology available in the classroom context. Computers and other accessories should be provided both in and outside the course to facilitate student teachers' learning and to allow students to practice their skills with this equipment.

Acknowledgements

This work was financial supported by The Graduate School Kasetsart University and The Institute for the Promotion of Teaching Science and Technology (IPST).

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