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Learning how to design a technology supported inquiry-based learning environment

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Abstract

This paper describes a study focusing on pre-service teachers' experience of learning how to design a technology supported inquiry-based learning environment using the Internet. As part of their elective course, pre-service science teachers were asked to develop a WebQuest environment targeting middle school students. A WebQuest is an inquiry-oriented lesson format in which most or all the information with which learners work comes from the Internet. The study examined participants' experiences and reflections. Qualitative research methodology was used to analyze the collected data. The findings of this study showed that WebQuest is an effective teaching tool and that participating pre-service teachers had a positive experience of developing it as part of their study. This experience positively affected their content knowledge and understanding of technology supported inquiry learning environments, allowing them to learn how to create an inquiry based and technology supported lesson. All participants indicated their intention to use WebQuest in their future teaching practices.

Key words: *technology supported inquiry, Internet safety, pre-service teacher education, inquiry-based learning, WebQuest*

Introduction

Creating an effective learning environment for students has been the priority of education for many decades. In science education in particular, many organizations have promoted the idea of developing an understanding of the question driven and open-ended nature of science among students (AAAS, 1993; NRC, 1999; Project 2061). To achieve this goal, many educational organizations and researchers accept the value of inquiry learning, and helping science classrooms to make the transition to inquiry learning environments is a globally accepted approach to enhancing science education (AAAS, 1993; Bishop 2002; Bruce & Davidson, 1996; Haury, 1993; NRC, 1999; Project 2061 [AAAS, 2001]). Inquiry learning provides an opportunity to integrate content and process in science teaching, the importance of which has been emphasized for the last half century.

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National Science Education Standards [NSES] (NRC, 1996) defines inquiry as "the activities of students in which they develop knowledge and understandings of scientific ideas, as well as an understanding of how scientists study the natural world" (p. 23). According to Anderson (2002), inquiry is the central word for "good science teaching and learning" (p. 1). In the 21st century, the learner's role has become more active and collaborative, and involves being able to access information from multiple sources and media (Bishop, 2002). Such learners should be able to pose questions, plan and pursue open-ended questions, investigate, analyze and communicate results in inquiry learning environments (Anderson, 2002; Blumenfeld et al., 1994). Edelson (1999) identifies three benefits of inquiry based learning: acquiring general inquiry abilities, acquiring specific investigation skills and developing an improved understanding of the concepts of science.

Regardless of the benefits of inquiry learning, there have been roadblocks in the process of implementation. Four dimensions of constraints have been identified in the literature: teaching, policy, school culture, and student constraints (Anderson & Helms, 2001; Kim, Hannafin, & Bryan, 2007). Technology can provide an alternative approach aiding the overcoming of these issues of implementation (Kim, Hannafin, & Bryan, 2007).

Technology supported inquiry learning environment

The attention of educational researchers and organizations has been drawn to the successful use of technology in education, especially to support inquiry based education for promoting scientifically and technologically literate citizens (American Association for the Advancement of Science [AAAS], 1993; National Research Council [NRC], 1996; Turkish Science and Technology Program [İlköğretim Fen ve Teknoloji Dersi Öğretim Programı] (MEB), 2005).

Many researchers point out the importance of integrating technology, and recommend technology supported inquiry-based learning environments (Barab & Luehmann, 2003; Edelson et al., 1999; Kim, Hannafin & Bryan, 2007; Kim & Hannafin, 2004). The benefits of integrating technology into inquiry learning environments include: giving students the opportunity of experiencing scientific modeling (Chang, Quintana, & Krajcik, 2010), using dynamic simulations (Barab et al., 2001; Colella, 2000; Edelson, Gordin, & Pea, 1999; Pallant & Tinker, 2004; Wilensky & Reisman, 2006) and working with actual scientific data through involvement in scientific experimentation. (Krajcik et al., 1998; McDonald & Songer, 2008; Metcalf & Tinker, 2004). As researchers (Chang et al., 2010; Geir et al., 2008; Gerard et al., 2011; Lee, Linn, Varma, & Liu, 2009; Quintana et al., 2004) suggest, students who use these approaches in science achieve significantly higher learning outcomes than those using a traditional textbook approach.

Although technology integration into science education benefits student learning, there are challenges and limitations, such as lack of time to design learning environments, and teachers' proficiency and confidence in using technology for inquiry. Technology supported inquiry learning (TSIL) may be a solution to such challenges and limitations (Lakala, Lallimo, & Hakkarainen, 2005). Edelson (2001) identifies TSIL as an alternative approach that integrates computers into the science education curriculum.

The teacher is one of the key players in promoting successful TSIL environments. The first step is for teachers to develop an understanding of the fundamentals of TSIL, as well as the ability to transfer their understanding into practical applications of web-based technologies.

During this process, the teacher's role changes to that of an 'organizer' (Lakkala 2005). As Gerard et al. (2011) state, teachers may be more involved in promoting student learning within technology enhanced learning environments than with the technology itself. Teachers' pedagogical competency thus plays a vital role in providing effective inquiry environments (Lakala, Lallimo, & Hakkarainen, 2005). Integration of technology into a learning environment may be hindered by (e.g.) technical issues, differences in student abilities, and the teachers' ability to act as a guide for students (Gerard et al., 2011; Songer, Lee, & Kam, 2002; Varma, Husic, & Linn, 2008). These limitations may cause teachers to be reluctant to use technology in their classrooms due to a lack of guidance (Anderson, 1995; Varma, Husic, & Linn, 2008). Teachers' lack of experience in implementing instructional technologies within inquiry science learning environments has been reported by researchers (Fishman et al., 2004).

In addition to the teachers' lack of experience, there are other challenges in using technology such as the Internet. Through integration of computer related technologies into instruction, teachers' use of different applications including the Internet have increased in inquiry classrooms. Today the Internet provides access to vast amounts of information through digital libraries, museum websites, simulations and other applications. At this point, the pertinent questions are: How should we use the Internet to support learning? Who will decide how it is used?

Since the Internet was first used in schools in the 1990s, there have been 'safety' concerns for teachers. Chou and Peng (2011) refer to the Internet as a 'double-edged sword' due to the nature of the available information. While the Internet provides valuable resources and possibilities for students, some of these may not be reliable or age appropriate, such as chat rooms, gambling sites, commercial material and sexually related content etc. (Livingston, 2003). In TSIL environments, such 'safety' concerns are the responsibility of teachers.

With these potential challenges, teachers may be reluctant to use the Internet and related technologies, and it is important to help them develop the necessary understanding and skills. Availability of supplementary professional development materials may make the integration process much smoother for teachers. Therefore, there are many initiatives supporting teachers and their professional development.

There are programs and projects promoting inquiry-based teaching, technology integration into education and technology supported inquiry learning globally. Some of the European and North American projects focusing on teachers' professional development and the development of blueprints for successful methodology, in particular for teaching and assessment, include:

- ESTABLISH (European Science and Technology in Action: Building Links with Industry Schools and Home)
- PROFILES (Professional Reflection Oriented Focus on Inquiry-based Learning and Education through Science)
- Fibonacci (Disseminating Inquiry-based Science and Mathematics Education in Europe),
- POLLEN (A Community Approach for a Sustainable Growth of Science Education in Europe),
- PRIMAS (Promoting Inquiry-based Learning in Mathematics and Science at both Primary and Secondary Levels Across Europe)
- SAILS (Strategies for Assessment of Inquiry Learning in Science)
- Scientix (Community for Science Education in Europe)
- S-TEAM (Science-Teacher Education Advanced Methods)
- ITCOLE (Innovative Technology for Collaborative Learning and Knowledge Building)
- LeTUS (Learning Technologies in Urban Schools)

- GLOBE (Global Learning and Observation to Benefit the Environment)
- KGS (Global Scientists)
- WISE (Web-based Inquiry Science Environment)
- Public Understanding of Science (Netherlands)

Today, many national leading educational organizations recommend the use of educational technologies as part of teaching and learning, e.g. National Research Council (NRC, 1996), the International Society of Technology in Education (ISTE, 2008), the National Educational Technology Standards (NETS) (ISTE, 2000), British Educational Communications and Technology Agency (BECTA, 2010) and Turkish Science and Technology Program [İlköğretim Fen ve Teknoloji Dersi Öğretim Programı] (MEB), 2005). Therefore, graduating teachers are expected to integrate educational technologies into their own practice. As research suggests, teachers' prior experience with technology influences their future teaching practices (Weil, Rose, & Wugalter, 1990).

As can be seen from the above, inquiry-based learning and technology supported teaching has received considerable attention from educators as well as policy makers, in order to improve the quality of education. In Europe, especially, these initiatives involve educators from multiple countries, and prioritize technology supported inquiry learning. Pre-service teacher education programs should therefore provide teachers with an understanding of inquiry, the skills necessary to integrate technology into inquiry-based learning environments and opportunities to experience these environments (Kim, Hannafin, & Bryan, 2007). However, there are very few pre-service teacher education programs that "prepare teachers to use technology-enhanced materials to enhance inquiry learning" (Gerard et al., 2011, p.409).

In this study, we provided pre-service teachers with opportunities to experience inquiry as learners, as well as to be TSIL environment designers. WebQuest was used as the instructional medium, as it has the potential to overcome barriers in implementing TSIL environments. Well-designed WebQuests can create authentic learning environments, which enhance student motivation through providing multiple resources for acquiring knowledge.

WebQuest

The first WebQuest application was developed in 1995 by Bernie Dodge and Tom March of San Diego State University, to create an inquiry-based learning environment where knowledge is obtained partially or completely from the Internet. With its scenario-based structure, WebQuest presents a TSIL environment where students are expected to solve a problem using six components: introduction, task, process, resources, evaluation and conclusion. MacGregor and Lou (2005) define WebQuest as a student-centered approach that enables students to analyze problems, synthesize knowledge and use higher order thinking skills. It allows students to directly participate in problem solving, thereby becoming active learners (Perkins & McKnight, 2005; Lowry & Turner, 2005). WebQuest is structured as a problem-solving task, which allows students to pursue open-ended questions and participate in authentic learning environments. The structure of WebQuest fits perfectly with the nature of inquiry based learning as identified in the literature (Blumenfeld et al., 1994; Edelson, 2001; Mistler-Jackson & Songer, 2000; Sadler, Whitney, Shore & Deutsch, 1999). It allows students to go beyond collecting information and requires them to synthesize this knowledge and draw their own conclusions (Abu-Elwan, 2007). WebQuest provides 'safe' Internet resources for students, and limits the number of relevant resources, thus preventing students from being overwhelmed (Summerville, 2000).

There are no grade level restrictions in using WebQuest. WebQuest has also been used in experimental teacher education programs to improve pre-service teachers' ability to integrate technology into teaching and learning (Manning and Carpenter, 2008; King, 2003; Summerville, 2000; Zheng et al., 2004). King (2003) emphasizes the importance of using WebQuest to provide pre-service teachers with a positive experience of technology, and to improve their self-efficacy in using technology in the classroom. However, in general, pre-service teachers lack teaching experience and therefore have a limited understanding of students' knowledge and skills. Therefore, developing a WebQuest may be a challenging task for them (Wang & Hannafin, 2009).

Research questions

This study therefore aims to explore WebQuest as a teaching and learning tool in undergraduate teacher education. For this purpose, pre-service science teachers took part in the study as WebQuest developers. We investigate the following questions:

1. What are the opinions of pre-service science teachers on the development and application of a WebQuest inquiry-based learning environment?
2. How do pre-service science teachers perceive WebQuest as a teaching tool?
3. How do they intend to use WebQuest in the future, from a developer's point of view?

Methodology

The study was conducted during the 2009-2010 fall semester at a major university in Turkey, with 22 pre-service teachers. All participants had taken two basic computer skills courses, including webpage design, during their second year, and had taken 'Science Method Course I' during their third year, the course content of which included *foundations of constructivist learning* and *creating inquiry-based learning environments in science teaching*. Nevertheless, none were familiar with the concept of WebQuest and creating an inquiry-based online learning environment prior to participating in the elective course 'Computer Assisted Science Education', which models exemplary work on the integration of ICT into science teaching and allows students to practice what they have learned, including the development and use of WebQuest as a teaching tool.

At the beginning of the 'Computer Assisted Science Education' course, the principles of inquiry-based learning environments in science teaching, and of web page design, were reviewed to ensure that all participants possessed the necessary knowledge and skills. The rest of the course was dedicated to the development of WebQuests. For this purpose, students worked individually or in pairs, according to individual preferences. The design phase of the WebQuest consisted of four stages: topic selection, scenario development, finding resources and design itself.

The first stage required pre-service teachers to select a topic for the WebQuests from the elementary science and technology program in which they were majoring. There were no other restrictions in terms of grade level or topic. Each individual participant /pair was asked to present their topic and receive approval from the instructor before writing their WebQuest scenario in the second stage.

To assist participants with this process, the following guiding questions were provided:

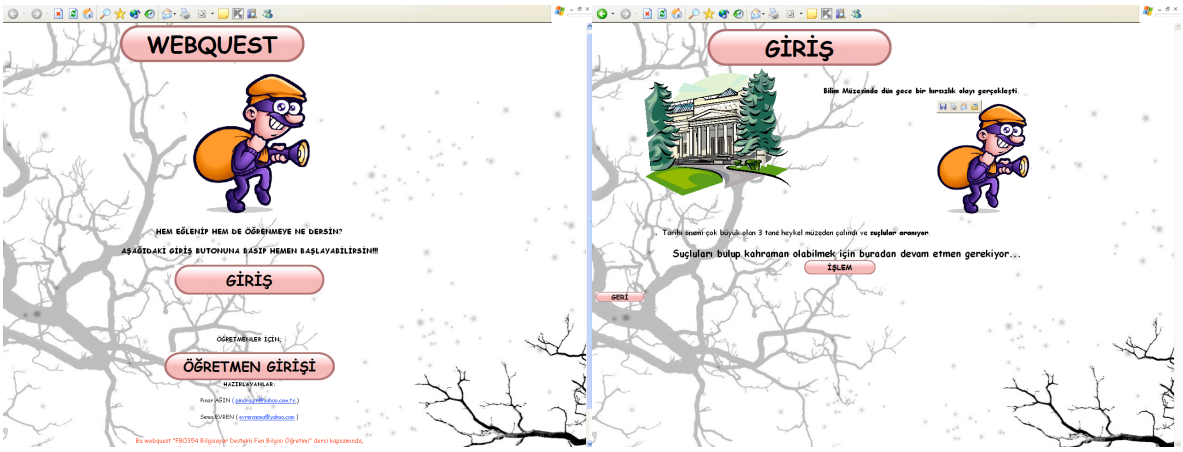
1. What are the expected learning outcomes from your WebQuest?

2. Why are these learning outcomes important?, and
3. How can students apply these learning outcomes to different disciplines?'

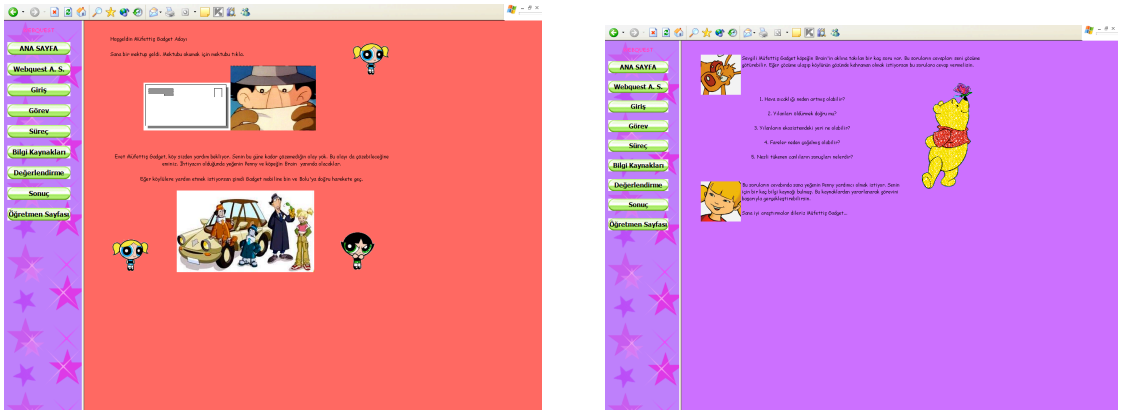
Two weeks were allocated for the scenario development process. Participants were expected to share their scenarios with their classmates each week and make any necessary changes based on feedback.

The third stage involved finding resources to be used in the WebQuest. These could be from published books or the Internet, the main criteria being safety and age and content appropriateness. Internet safety issues were revisited and discussed.

In the last stage, students designed their WebQuests and posted these on-line for review and feedback from their classmates. The following figures 1-4 show some of the samples of WebQuests designed by the students.



Figures 1 and 2. WebQuests designed by the students



Figures 3 and 4. WebQuests designed by the students

Data collection and instruments

A questionnaire consisting of five open-ended questions was designed and administered to the participants, based on an extensive literature review and opinions from two experts in science and technology education. The questionnaire focused on three main themes:

- Participants' opinions on the design and use of WebQuest as a teaching tool;
- Participants' opinions on the advantages and disadvantages of such a teaching approach;
- Possible obstacles during the development and application of WebQuest.

Data Analysis

Qualitative research methodology was used during the analysis of participants' responses. Four main themes - identified by March (1998) - were used to form the basis of the analysis. However, as the data analysis progressed, it became apparent that these four themes were not sufficient to categorize participants' responses. Another framework, including new themes, was therefore developed. Responses to the questionnaire were coded and analyzed by two researchers independently, and further themes were identified.

Results

The resulting themes and subthemes are presented in Table 1. Four themes were identified from the analysis: 'Motivation,' 'Learning,' 'Technology,' 'Teacher as Developer.' Participants' comments were coded as T1-24 throughout the study.

Table 1. Identified themes and subthemes

Themes	Subthemes
Motivation	Scenario based environment Visual aspect Fun learning environment
Learning	Teacher aspect of learning Student aspect of learning Assessment
Technology	Accessibility Skills & ability level Content limitations
Teacher as Developer	*(No subthemes identified)*

Theme: Motivation

Participants identified motivation as a leading aspect of WebQuest in terms of student learning. For this theme, participants' comments were grouped under the subthemes 'Scenario based learning,' 'Visual aspect' and 'Fun learning environment.'

Subtheme: Scenario based learning

The structure of a WebQuest deploys a scenario-based framework, using role-play to solve problems. The participants identified that this structure helps students to:

- Engage in learning environments through direct participation, and take responsibility for their own learning.
- Understand the main idea of the intended topic in a short period of time.
- Make real-life connections between the task and the intended topic.
- Make decisions during the task, thereby improving critical thinking ability

As a participant commented on this subtheme:

> Through the lesson, students will make connections with real-world situations. (T2)

Subtheme: Visual aspect

Two main advantages were identified in the 'Visual Aspect' of WebQuest. First, WebQuests can provide video and audio materials, which are motivating for student learning. Secondly, such materials allow students to make real-world connections by experiencing the natural phenomena that scientists work with as part of scientific inquiry. Disadvantages included the potential for distraction from the task due to excessive use of visual materials.

Subtheme: Fun learning environment

Participants commented that WebQuest is an effective learning tool, and creates a fun and engaging learning environment with its scenario-based framework. Specifically, role-play motivated students, and enabled them to grasp the main idea of the topic while having fun.

> WebQuest can be an effective learning tool when it's structured around an interesting scenario. It can be a good alternative for students who are bored with paper-based teaching approach. (T24)

> Students will be motivated in a fun learning environment while reaching the knowledge. (T1)

Theme: Learning

Participants identified the subthemes: 'Teacher aspects of learning,' 'Student aspects of learning' and 'Assessment.'

Subtheme: Teacher aspects of learning

There were two aspects to this: teachers as learners and teachers' intention to implement WebQuest in their practice. In terms of the impact of WebQuest development on their own learning, participants cited increased levels of knowledge about their chosen topics, resulting from the experience. One of the participants commented:

> While developing my WebQuest, I needed to do research about the topic. I had to investigate if the content knowledge and objectives that I'm planning to use were appropriate or not. I was involved in the process; therefore, I can say that my own knowledge has increased as well. (T1)

As the participants had to research the content as well as the materials for their WebQuests, they also had to evaluate their own content knowledge, and improve it if necessary. All participants stated that they intended to use WebQuest in their own classrooms. They realized that it benefits the learning process and wanted to ensure that their students experienced it, regardless of any disadvantages such as issues of access [to ICT].

> I might not be able to use this [WebQuest] in my classroom because of the limited access. Therefore, I would tell my students to visit my website to do research as their homework. (T9)

Subtheme: Student aspects of learning

This subtheme includes comments on the nature of the learning environment and effects on students as individual learners. Participants identified the following benefits of learning in WebQuest environments:

1. It is flexible enough to allow students to work at their own speed.
2. Its capacity for individualization and fun can promote sustained learning,

3. Through problem-based learning environments, students are motivated to do research and therefore to become active learners.
4. Students can access content knowledge whenever required.

Furthermore, the stepwise approach used in WebQuest scenarios, allows students to achieve the expected learning outcomes gradually, in a student-centered manner.

> The students will be involved in a scenario and the task would require them to do research that enables them to be active learners. (T1)

Subtheme: Assessment

Pre-service teachers identified WebQuest as a teaching tool that enables easier and more individualised assessment of students. Products such as WebQuest allow teachers to evaluate student performance and students can also evaluate themselves with WebQuest.

> It is easier to assess students and provide feedback. (T5, T21)

> Allows individual assessment and instant feedback. (T20)

Theme: Technology

This theme focuses on three main subthemes: 'Accessibility,' 'Skills and Ability Level' and 'Content Limitations.' Technology related comments and issues described by the participants were categorized within this theme.

Subtheme: Accessibility

This includes participants' comments on hardware, resources and up-to-date information. The Internet has become a vast source of easily updated information. The use of WebQuest, in particular, allows students easy access to up-to-date science and technology related content. The Internet also provides various video and audio resources for teachers, which have a wide range of uses in education. Another advantage of WebQuest is that it allows students to experience the lesson whenever desired, without the classroom environment, and without requiring the teacher's presence.

Today, students use the Internet as a primary resource for research. However, this can pose serious safety issues such as Internet predators, unsuitable content etc., especially for younger students. One of the biggest advantages of WebQuest, when used as a teaching tool, is its ability to allow students safe Internet access. It uses predetermined links to guide students during the task, at the same time allowing them easy access to resources:

> [its] advantage is to be able to reach various resources on the Internet. (T10)

> It allows [students] to use the Internet safely. (T23)

Although pre-service teachers identified WebQuest as an effective and motivational teaching tool, it has limitations. Some of these identified by participants include issues of access, particularly around 'Hardware access' and 'Internet related issues'. Any hardware related issues have to be resolved by the teacher. 'Internet related issues' referred to connection and resources. As WebQuest relies on Internet access to conduct searches and other related tasks, such access is required for each computer assigned to the students. This may not be possible

for every classroom. Another challenge is the responsibility of teachers to ensure that all the provided links are active and up-to-date.

Subtheme: Skills and ability level

This subtheme includes comments on both teachers' and students' skills and ability levels regarding computer use. WebQuests require a certain level of computer competency from both teachers and students, and participants were concerned about varying levels of student ability. Conversely, an additional benefit of using WebQuest is the improvement in technology skills that students knowingly or unknowingly acquire. Teachers play a guiding role when using WebQuest. However, if they are working with students who have higher levels of competency in computing than they do, this may result in self-confidence issues, resulting in teachers avoiding computer use.

> The ability level and prior knowledge difference among students may cause problems and cause delays in lesson.(T26)

> I can say that it is an effective tool. However, teachers needs to consider about student's prior knowledge, time and how it is applied. (T7)

In terms of *content limitations*, the scenario-based role-playing nature of WebQuest is not suitable for all the content of science and technology programs.

> Sometimes too much visual information may distract students away from the task…(T3)

> Advertisements on the Internet may take students' attention away …(T24)

Theme: Teacher as a developer

All participants learned how to develop their own WebQuests. Although they all stated that they intended to use WebQuest in their classrooms, some mentioned that, because of difficulties experienced at the planning and development stages, they would prefer to use existing WebQuests rather than developing their own.

> I would of course use high quality WebQuest that are available on the Internet. However, I don't think I would develop one by myself. (T10)

As WebQuest has only very recently been accepted as a teaching approach in Turkey, there are few Turkish language versions that can be used with the current science and technology program goals. The available WebQuests are mostly in English and therefore are not suitable for use in elementary education classrooms. To overcome this obstacle, participants suggested the development of a new WebQuest by pre-service teachers during their undergraduate study. This would provide a WebQuest of appropriate quality for teachers to use in science classrooms. Developing a high quality WebQuest, however, would be a time consuming and difficult process which participants stated they would be reluctant to undertake. Further concerns on this topic were stated as:

> for teachers, it takes too long to develop…(T2)

> WebQuest which are developed without consideration may create more harm than benefit…it takes time to develop. (T3)

Some of the difficulties reported for the development phase were finding appropriate and up-to-date websites to use as resources, and deciding on the sequence of the resources. External

websites might include unwanted elements such as advertisements, or be linked to other websites, which could divert the students' attention from the task. Selection of such resources, therefore, should be done discerningly. There were limited numbers of available resources for the WebQuests targeting elementary school students, in particular grades 6 to 8. Participants also emphasized the importance of focusing on the appropriate student profile, including student grade level and abilities, during the development of WebQuests.

Conclusion

This study provided pre-service teachers with their first experience of WebQuest; both as developers and users. They reported it as a valuable teaching tool despite the limitations and disadvantages identified. In general, they stated that they would use WebQuest as a teaching and learning tool in teaching practice. Similar findings were also reported in a study conducted by Köse (2007) with pre-service teachers.

Technology supported inquiry based learning environments such as WebQuest, allow educators to create learning opportunities that are student-centered, motivating, and participatory. Such environments are demanding for teachers, but since technology has become a significant part of supporting the learning process, teachers should be prepared to use it effectively in their classrooms (Russell et al., 2003). As both teachers and pre-service teachers are reluctant to use instructional approaches with which they feel uncomfortable (Ravitz et al., 1999; Kim, Hannafin, & Bryan, 2007; Gerard, 2011), especially when technology is involved, it is important that they acquire competence in new instructional techniques and materials such as WebQuest. Integrating these instructional technologies into teacher education would improve teachers' competence levels and increase their tendency to use such techniques in their classrooms.

Overall, participants believed that experiencing the development of a WebQuest had a positive impact on their content knowledge and understanding of technology, especially the use of WebQuest in classrooms. Kundu and Bain (2004) report a similar experience of using WebQuest in their own study, identifying WebQuest as a rewarding experience for participants, engaging 'their creativity, critical thinking, and problem solving skills.'

Recommendations

Teachers and pre-service teachers need to stay informed about WebQuest development and use in instructional practices. This awareness can be provided through integration of WebQuest and its applications into pre-service teacher education courses.

We recommend deploying a structured development format consisting of the four stages used during this study. The benefits of this approach are twofold. Firstly, pre-service teachers develop an understanding of WebQuest and its uses. Secondly, they learn how to create an inquiry based and technology supported lesson. The researchers recommend investigating the impact of this teaching approach - using WebQuest as a teaching tool - on participants' future teaching practices in the long term.

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