Integrating Technology into Project-based Learning in a Science Curriculum Development Course

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Abstract

This study examines the integration of technology in the project-based learning (PBL) environment of a science curriculum development course in a university in Bangkok, Thailand. Fifteen pre-service science teachers in a master's degree science education program participated in the study to create a variety of projects using technology as a learning tool. Each student had the opportunity to select the technology for their own project. The results showed that the students exhibited the ability to choose and apply appropriate technologies to grow their understanding of science curriculum development through project creation. The results produced strong evidence of the students' problem-solving skills and collaborative capacities.

Keywords: Project-based learning, technology integration, science curriculum development

Introduction

The purpose of the science curriculum development course that served as the setting for this study was to help the master students understand the concepts and principles of curriculum development in terms of curriculum theory, the

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history and development of science curricula, and educational vision and plans in both Thailand and abroad. Students of the course identified guidelines for developing science curricula concurrent with the advances of science and technology and national science standards. This required the ability to search for research studies related to science curriculum problems, trends, and development. The main goal of the course was that its students would be able to develop school-based curricula. The researcher of the present study, who was responsible for this course for three years, found that students who had already completed Bachelor of Science degrees typically experienced several difficulties in the course. Most claimed that the content was difficult and boring, and many did not have even basic knowledge of education or curriculum design. Thus, the researcher sought a way to improve students' interest in and understanding of science curriculum development.

Project-based learning (PBL) provided a possible means for solving these problems. PBL is student-centered, using collaborative and reflective activities to get students to work together on real-world problems and challenges. Students construct projects based on their interests, abilities, and learning styles (Edutopia, 2008; Grant, 2002; The Buck Institute for Education [BIE], 2014). The projects observed in the present study aimed to bridge classroom knowledge (science curriculum development concepts and theories) and daily life situations (real-life teaching) (Grant, 2002; Krajcik *et al.*, 1994; Thomas, 2000). The class's project-based instruction prompted the students to investigate driving questions and authentic real-world situations and problems that propel activities related to science curriculum development ideas. The students worked collaboratively to create projects that addressed these questions and problems (Lin, 2008; Krajcik *et al.*, 1994; Thomas, 2000). This study was grounded in constructionism, which proposes that humans learn by making or constructing (Papert, 1980). Learning should also happen in an appropriate context where students are consciously engaged in constructing something using context-appropriate tools and media (Papert and Harel, 1991). The focus here is on learning through making, rather than just cognitive potential, and how ideas are formed and transformed when expressed through different media (Ackermann, 2001). Constructionism also concentrates on using technology as a tool for learning (Papert, 1980; Papert and Harel, 1991). In the observed class, technology was used for investigation, collaboration, and artefact development (Krajcik *et al.*, 1994). The students were required to create a project to solve their problems. The teacher is a facilitator who encourage students in a real life context (Thomas, 2000). They must assess student learning through project-creating processes. Because there are many kinds of projects—such as oral projects, multimedia, and work skills (Andrade, 2016; Grant, 2002)—a teacher must assess the process as well as the final product, using effective scoring rubrics (ALTEC, 2016a; Tamim and Grant, 2013).

Despite the limited amount of prior research on PBL and technology integration in PBL for higher education in the literature, extant results show the success of technology-integrated PBL in promoting student learning. For example, when PBL was introduced to the IT environment of three undergraduate chemistry courses, results showed that the model promoted student-directed scientific inquiry of problems in a real-world setting (Barak and Dori, 2005). In another study, higher education PBL's effectiveness at improving student learning and preparing graduates for professional practice was investigated. Students were encouraged to link theory to practice by solving real-life problems related to future professional contexts. The study's results indicated that PBL fostered deep-level learning and the acquisition of important skills for professional practice, as the involved project development provided an everyday context for linking theory to practice (Fernandes, 2014). These results demonstrate that using PBL allows students to relate their work to broader professional situations outside the academic world.

Objectives

The objectives of the present study are as follows:

1. To study how students develop understandings of science curriculum development within a technology-integrated PBL classroom.

2. To study students' abilities to use technology as a learning tool.

Methodology

This qualitative research followed the interpretive paradigm, which involves studying things in their natural settings and interpreting phenomena from the view of the participants in a social world (Bryman, 2001). The focus of this study was on understanding and describing graduate students' learning in a classroom where a PBL unit was implemented for 15 weeks. All activities were intended to promote the students' selection of technology to create a variety projects to show their understanding of science curriculum development. All learning activities were conducted through Edmodo, and student projects were created and published on various web applications and sites such as YouTube.

Participants

Fifteen graduate students enrolled in the science curriculum development course during the first semester of their first year. All held Bachelor's degrees in science and had received scholarships from the Project for the Promotion of Science and Mathematics Talented Teachers (PSMT), supported by the Institute for the Promotion of Teaching Science and Technology (IPST) in Thailand. These students were expected to become science teachers in enrichment high school science classrooms.

The Course

Before taking the course, students had little understanding of the goals of science curricula. Some students reported feeling bored or nervous in the class. Science Curriculum Development, which runs for 15 weeks at three hours per week, was designed and implemented to encourage students to promote their understandings of and ability to use technology as a learning tool when devising projects. When developing activities in this course, students were required to: 1) work collaboratively with each other and the teacher, 2) create meaningful projects during the learning process, 3) keep all projects realistic, and 4) use technology as a learning tool. The project-based activities provided students with an authentic learning opportunity in a collaborative environment, where they had access to a range of technologies and science curriculum development knowledge. Their main project was to develop an original science curriculum. Each group of students needed to propose their science curriculum outline at the beginning of the course. In the later weeks, the students rotated groups for different activities, but maintained their original groups when working on the science curriculum. Each group had to present the progress of their science curriculum five times throughout the semester. They had the last two weeks of the semester to revise their science curriculum before turning it in to the instructor.

The class involved making commitments from discussions about what kinds of projects students would create for each topic. For example, to study and present the history and development of science curricula, students use the internet to explore the technology tools appropriate for interpreting knowledge and presenting their understandings. The students learned several presentation mechanisms, such as tables, graphs, and timelines. Timelines were particularly relevant to the study of the development of science curricula, as they allowed students to create linear visualizations of that development. The students were encouraged to choose what software, applications, and online tools they would use. These learning projects led into the main project of the course—developing their own science curricula.

Data Collection

Classroom observations and a journal kept by the researcher were used to assess the students' understandings of science curriculum development and their abilities to use technology as a tool for learning. Student interviews, reflective journals, and projects were used as evidence of the students' understanding of and ability to use technology.

Data Analysis

Content analysis was conducted using the data from classroom observations, the researcher's journal, and student interviews, reflective journals, and projects (from which significant statements were categorized into themes). For dependability, a project-based learning expert was asked to audit the data analysis (Guba and Lincoln, 1989; Lincoln and Guba, 1985). Through this process, ambiguous analyses were revised and unclear project photos and interview data were removed.

Results

Five themes were emerged from this study: the promotion of student understandings of science curriculum development and technology integration; student abilities to use technology as a learning tool in PBL; student abilities to choose and organize technology when creating a project; and using technology to promote problem-solving and collaboration.

Student Understandings of Science Curriculum Development and Technology Integration

At the end of the course, most of the students exhibited an understanding of curriculum development across all topics. When discussing international science curricula, students were asked such questions as "what you know about international science curricula?" The students were asked to choose one country and study the science curriculum standard of that country. For this activity, students chose Plain English for their presentations. However, before creating Plain English, they had to construct a storyboard to visualize their ideas and present them to the class and instructor. After their presentations, each group uploaded their work to YouTube and responded to comments and questions by the researcher and fellow students. An example project is shown in Figure 1.

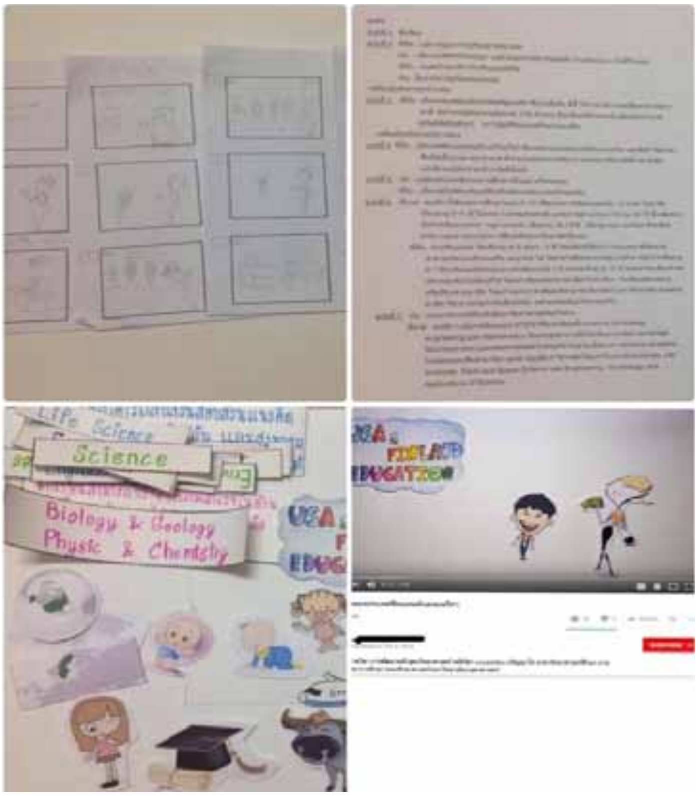

Figure 1: Group 2's project: Development of Plain English
(storyboard, script, pictures, and Plain English)

According to the analyzed classroom observations, this activity deepened the students' understandings of international science curricula. In addition to studying one country in detail for their own projects, the students had the opportunity to observe and compare science curricula in other countries as presented by their classmates. For example, S8 explained that "I like the Community Ecology curriculum of Singapore because the curriculum developers paid attention to community services. I think this is a good idea because the curriculum developers should be aware of context and people in that community" (S8-Reflective Journal 14), and S11 stated, "I have learned a lot from the other group presentations. I found that many countries focus on inquiry, constructivism, and attitude toward science. I think we can adapt this to develop our science curriculum" (S11-Interview 7).

From the many theories related to curriculum development, four theories were assigned in the present course: namely, those of Hilda Taba, Ralph Tyler, Malcolm Skilbeck, and Peter F. Oliva. The students were separated into groups, and each group was responsible for one theorist-based curriculum development model. Two weeks were allotted to complete the project, as it required the students to study many books and demonstrate their understanding by creating an infographic. Results indicated that this activity helped the students tremendously because they did not need to study all four theories; they concentrated on the theory assigned to their group and learned about the others via the other groups. All the created infographics were uploaded onto Edmodo, then were discussed using the following questions: 1) what are the similarities and differences of the four curriculum theories? and 2) which curriculum theory suits our country? The students compared the theories and gave suggestions regarding how to develop a science curriculum in Thailand.

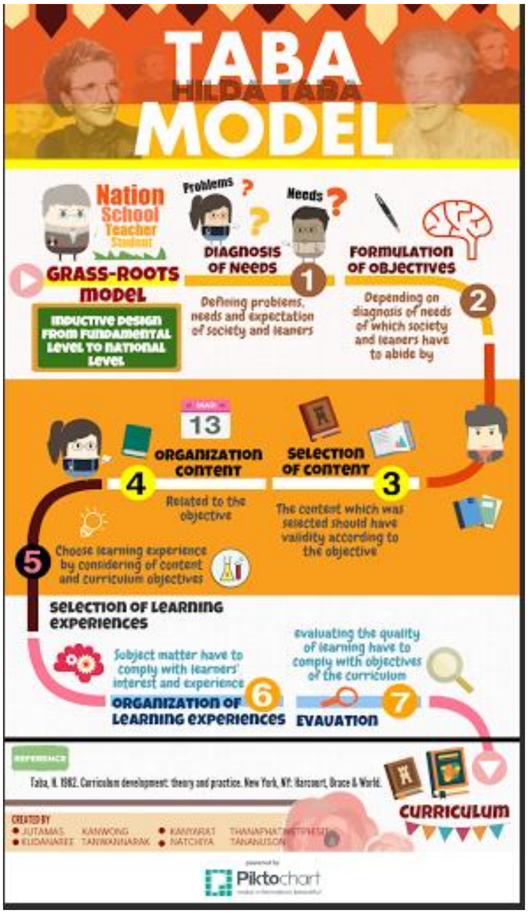

Figure 2: Group 3's infographic about the Taba curriculum development model

The students were given a similar project format when studying science curricula. Each group of students was asked to develop a poster to present their understanding of the topic. This required searching for a research paper about science curriculum development, which was quite challenging for the students. To help them, a guideline for studying research papers was provided, which asked questions such as "what is the research question(s) and research objective(s)?" to direct the students toward key information. Based on their readings, each group created a poster and presented what they learned from the research studies. S10 gave favorable feedback on this process, saying:

Our group learned a lot from my research study and other groups' presentations. We liked the presentation of Group 2 because they talked about many different approaches to implementing a science curriculum. We should present our study on how scientists work because we think we can that use in our country. (S8-Classroom Discussion 12)

At the end of the course, all students had to present their main project of a school-based curriculum; two weeks were reserved for the presentations. Analysis results indicated that most students exhibited an understanding of science curriculum development through the history and development of science curriculum, science curriculum standards, curriculum analysis, and school-based curriculum construction. The students showed anawareness that science is more than just content, and it is necessary to include the nature of science, science process skills, and scientific attitudes when devising a school science curriculum.

Student Ability to Choose Appropriate Technology

The students were asked to select and use technology as a tool for organizing and communicating their ideas. For example, each group of students selected an item of technology to present what they learned from their studied about science curriculum development. S3 explained why his group chose Microsoft PowerPoint, saying "we choose Microsoft PowerPoint for creating our poster because it is easy to use and appropriate for putting much information from the research paper onto the poster" (S3-Reflective Journal 12). Similarly, when studying the history of science curricula from international sources, most students used digital technologies to access, manage, integrate, and evaluate information to create their posters. S4 explained her choice of an application for creating a timeline about the history of science curricula as follows:

Our group was interested in the history of New Zealand's science curriculum. We found a lot of data from many websites and science curriculum documents. We decided to use http://whenintime.com/ to create a timeline of the history of New Zealand's science curriculum. Whenintime is a good application *because it is easy to use and edit. We can add more pictures and format it to help the others understand our ideas. Creating a timeline is a good way to show the developments and changes of the science curriculum from past to present. (S4-Reflective Journal 7)*

Figure 3: S4's timeline of the history of New Zealand's science curriculum

Another group selected a different application to create their timeline, as described by S5:

Our group studied Finland's science curriculum history. We got very good data from the PISA 2006. We wanted to present the development of the science curriculum and show each period in detail. We select Prezi as a tool for creating our timeline because this application has a "Zoom" function, so we can move and show each period. Moreover, Prezi is free and can add more photos, sounds, or clips. Prezi creates an .exe file, so it is very convenient to run on every computer. (S5-Reflective Journal 7). When studying curriculum development theories, the students reported a variety of reasons for selecting tools to create projects. S10, for example, chose the Piktochart application to create an infographic about Hilda Taba's curriculum development theory, explaining that:

Piktochart [https://piktochart.com/] is an online application, which has many cute and beautiful functions. I love to work with our group because everybody helps each other and shares ideas. I think everybody can understand the theory of Hilda Taba from our infographic. (S10-Reflective Journal 10)

In the topic of curriculum theories, S12 selected Canva application with the rationale that "our challenge was in how to summarize the main ideas about School-based Curriculum Development by Malcolm Skilbeck in our infographic. Our group used the Canva application [https://www.canva.com/], which has many cliparts suitable for our ideas" (S12-Reflective Journal 10).

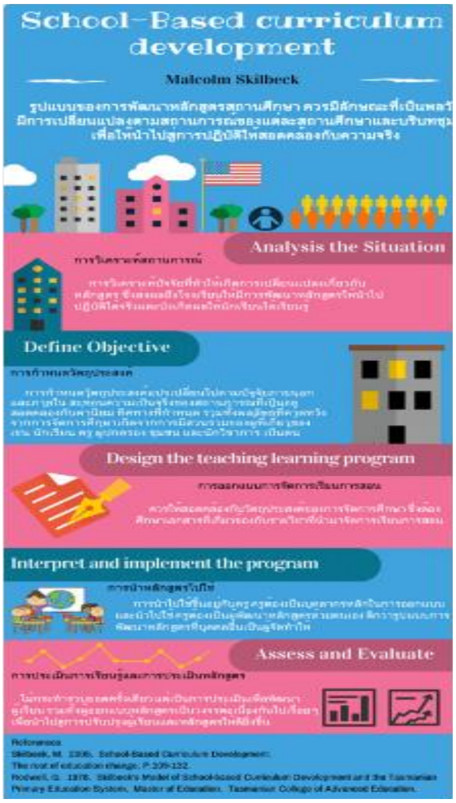

Figure 4: S12's infographic about the Skilbeck curriculum development model

The students used networking tools and social networks to access, manage, integrate, and evaluate information to create their projects. S8 explained how her group planned for creating their science curriculum as follows:

Our group made much progress in developing our science curriculum. We work all the time because we use Google Drive, so everyone can work from anywhere in the same file. Moreover, we used Line application for discussion and managing our project. (S8-Interview 5)

Further, most of the students demonstrated an understanding of the ethical and legal issues involved in using technology. S15 noted the importance of searching for and referring to quality data properly when creating the projects, acknowledging that "we have to be aware of copyright issues and ensure credibility of all resources" (S15- Reflective Journal 4).

Using Technology to Promote Problem-solving and Collaboration

By the end of the course, the students not only demonstrated an understanding of science curriculum development and the ability to choose and apply technology, but most exhibited explicit problem-solving and collaboration skills. Each group of students encountered different problems when creating their science curricula, and all demonstrated the ability to solve these problems effectively. Some students said they took ideas from other groups' presentations. S7, for example, explained that she was inspired by a friend's poster:

I got some ideas for developing our science curriculum from other groups. I found that some countries gave opportunities to the teachers and students to critique their national curriculum. I think this is a good idea for developing good curriculum in each area. (S7-Reflective Journal 14)

S11 described her group's process for creating their science curriculum, explaining that "we developed our science curriculum by searching for data from many documents and studying many school-based curriculums in our country and overseas" (S11-Reflective Journal 12). Further, many students reported getting ideas about how to create their science curricula by observing classrooms in schools. S1 described how her visit to a school had impressed her, saying "I found that if we gave the students chances to meet scientists or STEM career professionals, it will help inspire the students to love science. I will bring this idea to our science curriculum [main project]" (S1-Reflective Journal 15).

These responses indicate that most of the students recognized the advantage of collaboration. They showed that they could brainstorm, communicate their ideas, and show respect for others' ideas. For example, S10 said that "brainstorming helped us to improve our ideas" (S10-Reflective Journal 9). S7 showed her respect for other's ideas when they helped her solve problems, saying "we must respect others' ideas. Sometimes I found that my ideas cannot solve the problem, so I accept my friends' ideas" (S7-Reflective Journal 5). Moreover, the students described failure as an opportunity to learn and considered their teacher's feedback seriously, acknowledging that "sometimes we have failures, but we can correct them and learn from friends" (S9-Reflective Journal 4), and "I like your [researcher] feedback. It helps me know our mistakes and how to solve the problems" (S10-Reflective Journal 12).

Discussion

This research described how technology integration could be achieved in PBL. The results indicated that technology played an important role as a learning tool in the observed classroom (Papert, 1980). Technology tools not only promoted student understandings of science curriculum development but also encouraged technological literacy (Office of Superintendent of Public Instruction [OSPI], 2015). Students in the present study had the opportunity to choose and use technology to organize and communicate information, ultimately using digital technologies to access, manage, integrate, evaluate, and create information. Most of the students made reasonable technology selections when creating their projects, and using the technology informed their awareness of the ethical and legal issues surrounding technology use.

The course's main project—science curriculum development—focused on solving realistic problems and encouraged students to drive their own learning (Thomas, 2000). Each group of students was challenged to create a curriculum in their own way. Although each group encountered different problems, all demonstrated the ability to use effective ways to solve these problems and to identify and ask significant questions to clarify various points of view about the science curriculum. This showed the students' problem-solving capacities, as they independently selected appropriate technologies and solutions to resolve a variety of problems. All students worked collaboratively and creatively with others and were open and responsive to new and diverse perspectives (OSPI, 2015). The course's activities encouraged the students to investigate and work collaboratively with friends and teachers and to use technology to create and express their ideas through different media (Papert and Harel, 1991; Ackermann, 2001). The students constructed their own understandings of science curriculum development by creating meaningful projects during the learning process. The present study's findings are consistent with those seen in prior works (Barak and Dori, 2005 ; Tamim and Grant, 2013) that showed the success of PBL. Furthermore, the effectiveness of technology integrated with PBL indicates that it is successful not only in content subjects such as mathematics, science, and language, but also in professional subjects in higher education.

Conclusion This result indicate the importance of integrating technology into PBL to promote student understandings of science curriculum development. Instructors desiring to introduce PBL to their classes should consider technology integration and the following items as foundational criteria for PBL: 1) a learning environment that engages students to investigate and work collaboratively with others ; 2) the creation of meaningful student projects (not as homework) that require creativity and collaboration with other students, the teacher, or relevant experts; and 3) projects that are realistic and relatable to real-life situations.

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