Synergizing pedagogy, learning theory and technology in instruction:

How can it be done?

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Abstract: Instructional reform movements in the 1990s called for an effective and concurrent integration of various educational components. For effective classroom instructional reform, it was suggested that teaching method (pedagogy), learning theory, and technology be promoted concurrently to form synergistic relationship. Thus, the primary purpose of this paper is to report a research that investigated the use of constructivism (learning theory) and technology in project-based learning (pedagogy) in elementary school classrooms. This paper consists of three main parts. The first part introduces the idea of integrating elements of pedagogy, learning theory and technology in a synergistic manner. The second part outlines the research findings of the extent of such integration in an elementary school. The final part of this paper provides suggestion on how these elements can be integrated in an effective and synergistic manner in order to bring about an instructional reform in education.

Key words: instructional reform; learning theory and technology; synergizing pedagogy

1. Introduction

As it is true in many parts of the world, education has been going through a widespread reform. In the United States of America, initial attempts to reform schools in the 1960s and 1970s were designed to fix "broken" parts of schools. For example, individual reforms such as better math and science were introduced into the curriculum (Cicchinelli, 1999). It was later realized that simply fixing the "parts" did not work because other factors were not taken into consideration. Later in the 1980s, the direction of school reform shifted its focus from fixing the parts to fixing the whole. Thus, reforms such as new teacher standards, better salaries for teachers, and school report cards were introduced. Even these reforms were found to have had a limited effect (Fuhrman, Elmore, & Massell, 1993). In the 1990s, the direction of school reform moved towards comprehensive school reform. The comprehensive school reform movement called for not only combining the piecemeal efforts, but integrating them (Cicchinelli, 1999). This meant that various reform efforts should take place concurrently.

Similarly, reforms in educational practices related to teaching and learning also need a comprehensive and integrative approach. Bagley and Hunter (1992) identified three agendas of educational reform movements in the

literature: (1) a push for restructuring schools; (2) a constructivist and cognitive / information processing view of teaching; (3) a movement towards integration of technology in the school curriculum. Means and Olson (1995) wrote about the challenge teachers faced in the light of education reform movements as follows:

> The education reform movement challenges teachers to transform their practice by adopting high standards for all their students; new curricula emphasizing high-order skills; constructivist, student-centered teaching methods; and increasingly instructional uses of computers and other technologies (Means & Olson, 1995, p. 1).

For these reforms to be effective, various educational agendas not only need to be promoted concurrently (Sheingold, 1991), but they must also form a synergistic relationship (Bagley & Hunter, 1992). Thus, the research highlighted in this paper tried to bring together components of constructivist learning theory, technology, and pedagogy (project-based learning) in a synergistic relationship as proposed in the educational reform literature.

Although the philosophical roots of constructivism may go back many decades (Jonassen, 1991; Larochelle, et al., 1998), only in the recent past have educators shown a strong interest in constructivism (Brooks & Brooks, 1999; Larochelle, 1998; PCAST, 1997). Constructivism is a theory of human learning. The main proposition of constructivism is that learning means constructing, creating, inventing, and developing our own knowledge (Marlowe & Page, 1998). It defines knowledge as temporary, developmental, socially and culturally mediated. In its educational applications, constructivism supports students' active and creative engagement in various learning tasks. From the constructivist perspective, learning is understood as a self-regulating process of resolving inner cognitive conflicts that often become apparent through concrete experience, collaborative discourse, and reflection (Brooks & Brooks, 1993). It is thus an appealing alternative to traditional education practices in that it stresses higher and multiple forms of literacy and skills, self-reliance, and cooperation.

There is significant literature on project-based learning (Autodesk Foundation, 1998; Katz, 1994; Katz & Chard, 1989; Moursund, 1999), and on technology-assisted project-based learning (Delo, 1997; Harris, 1998; Laffey et al., 1988; Moursund, 1999; Moursund, Bielefeldt & Underwood, 1997; Polman, 1997). However, we know little about effectively implementing the use of constructivism and technology in project-based learning on a school wide basis. Thus, the overarching goal of research on which this paper is based on was to investigate how the components of constructivism, technology, and project-based learning are tied together as a coherent whole, and used to achieve a comprehensive instructional reform at the school level.

2. Convergence of constructivism, technology and project-based learning

The convergence of constructivism, technology and project-based learning is bringing together theories of learning, educational technology, and pedagogy. These three components of educational "tools", if implemented simultaneously, form the basis of the comprehensive school reform promoted in the 1990s. The comprehensive school reform movement of the 1990s called for integration of various educational components concurrently (Cicchinelli, 1999). A similar position was proposed by Bagley & Hunter (1992), who stated that the agendas of educational reform such as educational practices, learning theory and technology should be integrated in a comprehensive manner. For effective school reforms these agendas not only need to be promoted concurrently (Sheingold, 1991), but also must form a synergistic relationship (Bagley & Hunter, 1992).

Effective changes in educational practices and learning outcome may not be realized by just using a certain innovation such as a learning theory, methodology, or technology independently. The methodology used should be embedded within a sound learning theory that supports the method. In the study reported in this paper, the use of

project-based learning is viewed as underpinned by the constructivist theory of learning. The integration of technology further strengthens the convergence of learning theory and methodology forming the synergy of pedagogy, learning theory and technology. Trilling and Hood (1999) viewed learning in the knowledge age as the convergence of learning theory, knowledge tools, and knowledge work. Their view also supports the convergence of constructivism, technology, and project-based learning as proposed in this paper. Based on the work of Trilling and Hood (1999), learning theory can be linked to constructivism, knowledge tools to technology, and knowledge work to project-based learning. *The cognition and technology group at vanderbilt* (1996) also provided a similar view of the need to consider the three areas of educational practices, technology, and learning theory simultaneously.

3. Methodology

3.1 Main research question

In the original study, five research questions were formulated to study various aspects of the use of constructivism and technology in project-based learning. For the purpose of this paper, only one main research questions is used. The main research question is as follows: To what extent are constructivism, technology, and project-based learning carried out concurrently to form a synergistic relationship?

3.2 Research participants

The participants for this study are four teachers in an elementary school where project-based learning is implemented as an important focus of the school curriculum. All the teachers identified were involved in implementing project-based learning in their classrooms. These teachers volunteered to participate in this study and had the right to withdraw from the study at any time. In compliance with the human subjects protocol, the identities of all the teachers were protected and pseudonyms were used in the original study to protect confidentiality. The pseudonyms for the teachers involved in this study were Martha, Kelly, Joanna, and Jane.

3.3 Research site

The research site was an elementary school, located in the state of Oregon. The school employed project-based learning activities as an important focus of the school curriculum. To preserve the confidentiality of the research findings, a pseudonym was also given to the school. The school was named as Green Hill Elementary School. This school had seven teachers, including one head-teacher, and 143 students in grade one to five. All children are regularly engaged in a variety of multi-aged project-classes. Project classes are carried out every Monday, Tuesday, Thursday, and Friday from 1:10 pm to 2:40 pm. Several project classes are offered every three or four weeks. Students were allowed to choose projects from areas such as: social studies, science, art, music, drama, shop, among other topics. The project curriculum offers hands-on activities that encouraged children to choose project classes based on their personal interests.

3.4 Data collection

Based on the research questions and the phenomenon of interest for this study, a qualitative research methodology was used. A qualitative research approach was used to gather data through interviews, observations, and document analysis, to address the research questions regarding the use of constructivism and technology in a project-based learning setting in an elementary school. Acquisition of data from various sources allowed for triangulation, where various forms of evidence are used to achieve a more comprehensive understanding of the issues being studied.

During the data collection phase, each teacher was interviewed. They were interviewed by using a plan of semi-structured interview questions which were basically centered on the research questions. All formal interviews were taped-recorded and transcribed. Additional discussions and informal interviews were also conducted with the teachers. The discussions and informal interviews were recorded as field notes. For further clarification and questions, follow-up e-mail communications were carried out with these teachers. The e-mail messages were also regarded as field notes.

The project lessons conducted by each teacher for a particular group of students were observed throughout the entire duration of the project. Three of the projects observed lasted for three weeks. The fourth project lasted for four weeks. During each classroom observation, detailed field notes were produced. At the end of each day's observation, field notes were immediately word-processed and saved as a computer file. Throughout the observation period, efforts were taken to ensure that the field notes were word-processed immediately after returning from observation at the school. This was to decrease possible loss of additional data from memory.

In addition to the field notes describing the activities in the classrooms, notes in the form of analytic memos were also carried out during and after observation. Beside this, document analysis was also used as a method of data collection for the study. Teachers' preparations of project-based learning activities were observed. Students' projects were examined. Documents from the school such as the report card, district academic performance report, handbooks, newsletters, assessment materials, curricular materials used for the project-based learning activities, as well as notices from the bulletin boards were also regarded as sources of data for this study.

The summary and information of the four projects observed and studied in this research is shown in the following Table 1.

Table 1   Summary and information of projects studied

No.	Teachers	Grade Level	Title of Project	Description of Project
1	Martha	4-5	Land and Water	Do you like to dig in the dirt? Make streams and test how water affects our land? We'll start with the water cycle test flow of streams, test soils and conclude with designing home sites and testing them for stability.
2	Kelly	1-3	Wild and Wonderful Wetlands	Wetlands are outdoor areas with standing water during certain seasons. They are the homes for many animals, birds, and plants. We will study some wetlands in this city and in some other places in the world. We'll visit them, take water and soil samples, study the wild life, and learn about their plants. You will become scientist learning about a special type of natural environment.
3	Joanna	1-3	Africa and Kenya	Come learn about the continent of Africa and the country of Kenya. We'll learn about the Masai and have a member of the Masai come to visit our class. We'll make animal masks and animal heads that open their mouths. We'll make African designs on tee shirts and more!
4	Micro Worlds	3-5	Micro Worlds	Come explore the world around you, a fascinating world you cannot see with the naked eye. You'll learn about magnification, use various kinds of lenses and microscopes and study some of the amazing tiny creatures and things in your everyday environment.

4. Findings: Synergistic relationship of project-based learning, constructivism, and technology

The data collected and analyzed in this study revealed that the school periodically offered a list of about

seven to eight projects from which students can choose. Teachers planned extensively for these projects. They spend a lot of time planning a diverse range of instructional activities for the projects. Students had the choice to participate in the projects they were interested in.

At the implementation stage in the classrooms, teachers worked very hard and did a lot of preparation for the project classes. They used a variety of instructional strategies. These strategies included a combination of whole class instructions, discussions, students' hands on activities, video presentations, field trips, and bringing outside experts into the classrooms. All these activities were directed towards the theme of a particular project. The use of multiple instructional activities helped the students to stay focused, engaged, and motivated throughout the project classes.

Although the teachers expressed enthusiasm, and prepared extensively for their project classes, they did not consciously make a concerted effort to apply the principles of constructivism in their planning. This is inconsistent with the fact that almost all the teachers interviewed responded positively about applications of constructivism in project-based learning. However, during teachers' classroom practices of implementing the projects, a number of constructivist elements emerged.

The limited classroom application of constructivist principles was due to teachers' lack of integrating these principles in their planning. When teachers described how they planned their projects, they did not mention about integrating these principles. However, all the teachers indicated some general understanding of the constructivist theory. They were able to talk about constructivism despite some differences in their understanding. Most of them were also positive about the benefits of this theory in learning, they did not have the practical knowledge to apply various principles of constructivism in their project planning and classroom practices, as described in the literature. This was probably because none of the teachers had any training on how to integrate principles of constructivism in project-based learning.

In terms of technology, most of the materials, used by the teachers and students during project activities, were traditional instructional materials such as books and other print-based textual graphic materials. Technology tools such as hand lenses, microscopes, and other experimental materials and apparatus were also used. However, the use of electronic educational technologies was very limited. In all the projects observed, teachers used about two to three video presentations in each project class. Video presentations and overhead transparencies were used to provide information to students. Although computers were present in all the classrooms, ranging from three to seven in each classroom, and almost all computers were installed with good number of software programs, and were connected to the Internet, their use was very limited. Computers were only used in two of the four projects observed. In both these projects, computers were used marginally either to provide exposure, or to keep the students engaged in tasks such as drawing.

In all four projects observed, there were some elements of constructivism emerging in teachers' practices and various types of technology were used. However, constructivism and technology were not the primary focus of the teachers, either in planning or during projects' implementation in classrooms. When teachers are asked how they plan their projects for students, they never mentioned about integrating constructivism or technology. The teachers' priorities were on planning projects with multiple instructional strategies including hands-on activities that could keep the students motivated and engaged throughout the project. Teachers' planning, practice, and emphasis were more on the project itself and very little on constructivism or technology.

In this study, it was found that teachers did not make pre-planned efforts to integrate elements of project-based learning, constructivism, and technology concurrently to form a synergistic relationship. However, a

closer observation revealed that there were instances where such integration was present superficially. In the Land and Water project, Martha allowed interested students to explore a game-based software program called Eco-Master. The use of the computer program was relevant to the theme of the Land and Water project the students were involved in. The situation allowed students to have the opportunity to explore on their own in relation to what they were learning. That particular situation did bring together the elements of project-based learning, constructivism, and computer technology, to a certain extent. However, there were some limitations. Only five students had the opportunity to be engaged in the activity for fifteen minutes. As the teacher did not provide any guidance during the activity, the students ended up trying to make high scores in the game rather than understanding the contents presented through the game. Another instance of similar synergistic relationship was observed in the Wet and Wonderful Wetlands project conducted by Kelly. In the project, Kelly provided the opportunity for all the students to use computers to draw whatever they wanted about wetlands. The students drew pictures of animals and plants, which were related to what they were studying in the project.

Although the preceding two examples showed some evidence of convergence of project-based learning, constructivism, and computer technology, this integration was limited and the components were only loosely tied together concurrently to form a synergistic relationship. However, this school had the potential to integrate the three elements because project-based learning was already an integral part of the curriculum. Teachers generally had a positive view about the use of constructivism. The classroom's technology environment was also very conducive for the integration of project-based learning, constructivism and technology synergistically. If teachers had integrated all these elements in their planning and classroom practices, as described in classroom instructional reform literature, students' learning outcomes could have been significantly increased. The probable factor that impeded the synergistic integration was teachers' lack of practical knowledge on how to integrate principles of constructivism and technology effectively in project-based learning.

5. Synergizing pedagogy, learning theory and technology: How can it be done and what lessons can be learnt

Based on the literature and findings of this study, it is found that synergizing pedagogy (teaching method) learning theory (constructivism) and technology (computer technology) is a way forward to achieve a higher and better learning outcome. Although complete and holistic synergistic relationship between the three components is still less than optimal, such integration is not impossible to achieve. The following are suggestions on how such synergistic relationship can be achieved.

(1) Project-based learning must be an integral part of the school curriculum.

(2) Computer technology must be accessible to students and teachers in the classrooms.

(3) Learning theory such as *constructivism must be embedded* within the pedagogy used.

(4) In order to optimize the benefits and effectiveness of project-based learning, teachers need to stay current with the development of literature in this area. Besides implementing learning activities based on teachers' own beliefs and experience, teachers need to take advantage of the growing literature in the area of *technology assisted project-based learning*. By incorporating this new knowledge, the outcomes of project-based learning could be significantly increased.

(5) Teachers need *practical knowledge* of integrating elements of pedagogy, learning theory and technology.

(6) *Converge* project-based learning, constructivism, and technology that lead students to multiple learning

outcomes.

6. Conclusion

The goal of the original study was to investigate the use of constructivism and technology in the project-based learning environment of an elementary school. Before engaging in the original study, I anticipated and assumed that Green Hill Elementary School would serve as an exemplary model of how constructivism and technology can be integrated in project-based learning as proposed in the literature. This assumption was based on Green Hill's continued emphasis of project-based learning in their curriculum and the presence of favorable technology environment in their classrooms. In doing the study, I found there was a large disparity between research-based theories and classroom practices. I see a big difference between what self-directed, self-taught, well-intended, and experienced elementary teachers did with project-based learning, versus what has been demonstrated as desirable and possible in the accumulated literature base. Independent of what the literature advocated, teachers carried out their curricular activities with students based on their own experience and beliefs. The school's goal and philosophy also guided teachers' curricular activities. However, optimal synergy of pedagogy, learning theory and technology is only possible if the teachers had the practical knowledge and skills for such integration. One way of promoting the implementation of project-based learning, constructivism, and technology concurrently to form a synergistic relationship would be through teacher training and professional development. In teacher training and professional development programs, these elements should be presented simultaneously. Teaching method, learning theory and technology should be presented not in isolation but together. One way to do this would be for teacher trainers and professional developers with expertise on pedagogy, learning theory, and technology come together and provide the training as a team.

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