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The Effectiveness of Inquiry-Based Technology Enhanced Collaborative Learning Environment

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A complementary relationship exists between technology and inquiry based learning, the implementation of each one benefiting the other. Inquiry-based learning states that learning takes place in contexts, while technology refers to the designs and environments that engage learners. The purpose of this paper is to examine the effect of inquiry-based technology enhanced collaborative learning environment on students' learning experiences. Success has been reported in the development of course units using technology as cognitive tools, benefiting both graduate and undergraduate students.

Keywords: Inquiry-Based Learning, Constructivist Environment, Technology Enhanced Environments

INTRODUCTION

Inquiry-based learning is not a new approach in teaching but is not as widely used as it could be. In general, teachers complain that inquiry-based learning is too time-consuming and the curriculum is overloaded. Inquiry-based learning has to start earlier than in at primary school. It has to start in the Kindergarten and it has to prolong to middle and secondary school. Therefore, inquiry-based learning has to be supported because it is important as a tool for developing systemic, systematic and critical thinking skills, problem solving capabilities, and the creativity of students. Despite its merits, inquiry learning has encountered challenges in implementation. The most emergent problem is the shortage of appropriate instructional systems for inquiry learning or teaching in schools. A well designed and testified system for inquiry learning may benefit both teachers' teaching and students' learning. In addition, for inquiry learning to be more effective, it is necessary to strengthen the explorative learning motives of students, to inform them with exactly what scientific exploration skills are required, and to give them some understanding of the

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background knowledge (Edelson, Gordin, & Pea, 1999). Further, without appropriate guides, inquiry learning may turn out to be more of a hurdle for students, except for the brighter few.

Inquiry based-learning is a strategy about student exploration of knowledge. Though educators have provided different definitions of inquiry (Suthers, 1996; Looi, 1998; White & Frederiksen, 1998), they generally agree that there are at least four critical steps when conducting inquiry learning: 1- generating hypothesis, 2-collecting data, 3-interpreting evidence, and 4- drawing conclusions. Other research on inquiry models (Tinnesand & Chan, 1987; Igelsrud & Leonard, 1988; Suthers & Jones, 1997), suggest that the inquiry process should include six steps: 1 familiarizing; 2 hypothesizing; 3 exploring; 4 explaining; 5 revising; and 6 reporting. A four-phase of collaborative inquiry-learning model was proposed by Chang, Sung & Lee (2003). It consists of four phases: Phase 1: anchoring and planning, Phase 2: individual inquiry, Phase 3: collaborative inquiry, Phase 4: concluding group's results. Generally inquiry based learning cycle have five global steps: ask, investigate, create, discuss and reflect. One can conclude that abilities to do scientific inquiry include: identifying and posing questions, designing and conducting investigations, analyzing data and evidence, using models and explanations, and communicating findings. In order for learners to catch the focus in each step, the learning in each step is further divided into various learning activities, each corresponding to a learning objective, such as inquiry skills and collaboration skills. Inquiry-based learning assumes that learners takes an active role and construct their own knowledge base. Besides emphasizing a passive or active role of the learner, inquiry learning can be distinguished from other types in the type of learning processes. For inquiry learning to be meaningful, the processes that make up the empirical cycle should take place.

Previous research found that inquiry-based learning enhances students' learning achievement, especially in the aspects of problem solving skills, ability to explain data, critical thinking, and understanding of concepts in learning science (Chiappetta & Russel, 1982; Saunders & Shepardson, 1987; Haury, 1993). By using processes like collecting and classifying information, stating hypotheses, making predictions, and interpreting outputs of experiments, learners infer knowledge from the information given. This is essential, as a coherent knowledge base is not directly available in 'discovery situations' and knowledge is to be inferred (Shute, Glaser & Raghavan, 1989).

New perspectives in learning theories have encouraged researchers and practitioners to design, develop, implement and evaluate inquiry-based instructional models (Hmelo & Williams, 1998). There are several examples of how ideas of inquiry-based learning are put into practice by utilizing learning technologies (Bereiter & Scardamalia, 1993; Dede, 1998; Chang, et al. 2003). A growing body of research evidence demonstrates the positive effects of computer supported collaborative learning (Koschmann, 1996; Koschmann, Hall & Miyake, 2001). Inquiry-based activities create situations for students to be self-regulated and independent learners (Paris & Paris, 2001; Patrick & Middleton, 2002; Perry, VandeKamp, Mercer & Nordby, 2002). In Technology Enhanced Inquiry-based learning, the learners' active role is, in fact, assured.

In instructional situations, learning tasks may be ill structured and complicated. In order to cope with these types of tasks, students need to use learning strategies beyond the surface level, and apply their self-regulation skills. Moreover, strategic activity cannot be limited to specific strategies dealing with a single cognitive operation, such as writing, reading or problem solving. Rather, in complex learning tasks learners need to apply different types of strategies, monitor their activity and maintain coordination between multiple strategies.

Loveless (2003) points out, new technologies and the digital resources they access only provide opportunities for 'interaction, participation, and the active demonstration of imagination, production, purpose, originality and value'. Traditional forms of representing concepts and their relations are being challenged by the affordances of new technologies and different modes of expression are being made more accessible. Concept mapping has evolved from paper-and-pencil to technology based tools such as Inspirations (Inspiration Inc, 2006), Mind Manager (Mindjet Inc, 2006), SemNet (SemNet Research Group, 2006) and SmartDraw (SmartDraw Inc, 2006). These programs, in general, enable learners to interrelate the ideas that they are studying in multidimensional networks of concepts, to label the relationships between those concepts, and to describe the nature of the relationships between all of the ideas in the network. Royer & Royer (2004) compared the use of paper/pencil and computer tools for creating concept maps. The computer group created concept maps using Inspiration software on desktop computers. The paper/pencil group made concept maps in the traditional manner. The t statistic was used to evaluate the mean difference between the two treatments. The group using the computer created more complex maps than the group that used paper/pencil. This difference was significant. Using the technology to develop concept maps helps to minimize many of the construction and modification problems. The practical advantages of constructing concept maps electronically are similar to those of using a word processing program to write. There is an ease of construction, an ease of revision, and the ability to customize maps in ways that are not possible when using paper and pencil (Anderson-Inman & Zeitz, 1993; Anderson-Inman & Horney, 1996/1997). The advantages of technology-based concept mapping for learning may, however, go beyond such practical matters. The rich environment of the computer seems to invite information manipulation activities that help students build a more coherent view of the topic they are studying (Fisher, Faletti, Patterson, Thornton, Lipson, & Spring, 1990). It is possible that computer-based concept mapping helps to "reorganize mental functioning" in ways not possible outside the electronic medium (Pea, 1985).

This paper reports on inquiry based learning, the relationship between inquiry based learning and constructivism, the role of technology and the use of concept mapping, presentation software and reflective reports as a tool in inquiry based learning environment. This paper also presents a research which examines the effectiveness of inquiry based technology enhanced collaborative learning environment and its findings.

PURPOSE OF THE STUDY AND RESEARCH QUESTIONS

The purpose of this study is to analyze students' learning experiences through an inquiry-based technology -enhanced collaborative learning environment. In this study, we consider a small project that might provide data on the effectiveness of inquiry-based technology enhanced collaborative learning approaches to teaching. The main research question was: Does Inquiry-Based Technology Enhanced Collaborative Learning Environment affect students' learning experience. Four subquestions were derived from this main question. They were:

1. Are there any developmental differences between pre and post lesson plans generated by graduate students?
2. Are there any developmental differences between undergraduate and graduate students as shown by their concept mapping scores?
3. Are there any developmental differences between undergraduate and graduate students as indicated by their power point presentation scores?
4. Are there any developmental differences between undergraduate and graduate students as indicated by their reflective report scores?

The answers to these questions will contribute to the body of knowledge in the field of educational technology in general and learning environments in particular. It will provide the stakeholders, i.e. the educational leaders, relevant educational institutions, and researchers, with an insight about Inquiry-Based Technology

Enhanced Collaborative Learning Environment and uses of ICT in the classroom. Moreover, the study will allow faculty members and students to revise plans that are related to technology adaptation by highlighting the effects of Inquiry-Based Technology Enhanced Collaborative Learning Environment and ICT use in the classroom.

CONSTRUCTIVISM AND INQUIRY-BASED LEARNING

According to constructivist view of learning, learners construct their own understanding of the content under investigation. To achieve this end, learners will need learning environments supporting investigation, insight, reflection and discovery. The constructivist perspective is based on the premise that we all construct our own views of the world around us, through integrating our individual experiences and schema with new knowledge. Therefore, constructivism focuses on preparing the learner to solve problems in ambiguous situations. From a constructivist perspective, knowledge is not independent of the knower; knowledge consists of physical and abstract objects in our experience. For example, there is no one true definition of inquiry waiting to be discovered, but an understanding of inquiry is constructed by individual himself. According to Von Glasersfeld (1996), knowledge is adaptive; the worth of knowledge is not determined by its degree of truth, but by its viability. Those forms of knowledge about inquiry which are viable in classroom practice will become constructed forms of inquiry. For learners, knowledge about any content will be an individual construction through participation in the social and physical environment of the classroom.

Constructivists point that it is impractical for teachers to make all the instructional and learning decisions and give the information to students without involving students in the decision making process and assessing students' abilities to construct knowledge. In other words, guided instruction through questioning and inquiry is suggested where students are considered as the heart of learning process, and provided with guidance and concrete teaching whenever necessary.

Inquiry-based environment is one that provides and supports development of learning experiences where learners observe events, ask questions, construct explanations, test those explanations, use critical and logical thinking, generalize observed patterns, and consider alternative explanations. In this cyclical process: The learner asks questions. These questions lead to the desire for answers to the question (or for solutions to a problem) and result in the beginning of exploration and hypotheses creation. These hypotheses lead to an investigation to test the hypothesis or find answers and solutions to the question and/or problem. The investigation leads to the creation or construction of new knowledge based on investigation findings. The learner discusses and reflects on this newly-acquired knowledge, which, in turn leads to more questions and further investigation. Inquiry-based Technology Enhanced Collaborative learning environments can be structured in various forms. In one, learners are provided and guided with hands on activities and are required to arrive at their own conclusions through experimentation, observation, investigation and conjecture. One may also provide environments where learners are required to design and carry out experiments. Engaging in setting meaningful learning goals, determining which strategies to use and evaluating learning process are particularly important in technology-based learning situations involving open learning task structure, where these regulatory processes are not outlined by a teacher (Azevedo, Cromley & Seibert, 2004). Research reports that students learn much more when they are given inquiry based learning environments to first experiment on specific information relevant to a topic (Chiappetta & Russel, 1982). Salovaara (2005) indicated that the students who participated in the inquiry-based computer supported collaborative learning (CSCL) activities reported deeper-level cognitive strategies such as monitoring, creating representations and sharing information collaboratively.

He further reported that the students of the comparison group reported more surface-level strategies such as memorization. However, the findings concerning the utility of CSCL inquiry on cognitive learning strategies were not uniformly positive. In addition he found that the students of the comparison group reported significantly more strategies under the category of content evaluation. Nevertheless, the results suggest that computer-supported inquiry-based learning can enhance the use of cognitive strategies that support learning.

One way we can provide inquiry based learning environments for the students is through interactive activities which guide students through a process of inquiry learning. The main activity in a constructivist inquiry-based environment is solving problems. Students use inquiry methods to ask questions, investigate a topic, and use a variety of resources to find solutions and answers. As students explore the topic, they draw conclusions, and, as exploration continues, they revisit those conclusions. Exploration of questions leads to more questions and knowledge construction.

TECHNOLOGY AND INQUIRY-BASED LEARNING ENVIRONMENTS

Advocates for technology (Jonassen, Peck & Wilson, 1999) link the value of technology to teaching approaches that are inquiry-based, constructivist, project-based, or student centered. While varying in specifics, these approaches all emphasize the importance of students exploring ideas, conducting "hands on" investigations, engaging in projects on topics they choose, working collaboratively, discussing their ideas, and gaining conceptual understanding. In general, these approaches view knowledge as something individuals construct for themselves through action, reflection, and discussion; not as something that can be simply transmitted from teachers or books to students. Technology can be used to promote collaborative learning, in group projects (Scardamalia & Bereiter, 1994) and new approaches to working, learning, and interacting. Becker & Riel (2000), in a national survey of the uses of computers for teaching and learning, found that teachers who have a more constructivist orientation are more likely to make use of computers in their classrooms. However, the survey data does not tell us why this relationship occurs, or whether the combination of approach and technology has positive impact on student learning. When learning with technology focuses on doing inquiry-based learning, the following approaches are commonly adopted in classrooms:

- Technology is viewed as a tool, much like a pencil or pen, but considerably more powerful.
- Use of the technology is primarily taught in the context of solving problems.
- Students help one another with the mechanics of the technology; in fact, in many classrooms, students are the local experts on technological details.
- Talk about and around technology is as important as the technology itself, just as talk about how one finds and uses information is as important as the information itself.
- Technology is used to augment communication by expanding audience (e.g., over networks and by producing hard copy) and expressive options (e.g., mixing graphs and words) (Rubin, 1996).

It is well known that critical thinking and creative knowledge building requires flexibility and responsiveness that tends to differ by discipline and pedagogy. One approach that involves the graphical representation of ideas uses concept mapping to lay out ideas, processes, and their interconnection around a given problem area. Modes using both graphic and linguistic components are the graphic representational techniques of concept mapping and mind mapping. Constructivist learning theory argues that new knowledge should be integrated into existing structures in order to be remembered and receive meaning. Concept mapping stimulates this process by making it explicit and requiring the learner to pay attention to the relationship between concepts. Technology-based concept mapping provides a ‘mind tool’ (Jonassen, 1996) and a novel form of ‘conceptual’ or creative space for quality exploratory behavior. Jonassen (1996) argues that students show some of their best thinking when they try to represent something graphically, and thinking is a necessary condition for learning. Concept mapping connects concepts with relational links to produce propositions in diagrammatic form using multi-word labels and vectors (Novak & Gowin, 1984), and mind mapping (Buzan & Buzan, 2000) results in linked associations of concepts. The generation of linking features in concept mapping produces complex and intricate arrays that require constant evaluation and revision. The use of traditional media to construct concept maps can inhibit this generation.

Constructively communicating ideas is central to the whole inquiry process. At this point in the cycle of inquiry, learners share their new ideas with others. The learner begins to ask others about their own experiences and investigations. Shared knowledge is a collaborative process, and the meaning of their investigation begins to take on greater relevance in the context of the learner's society. Presenting their ideas to classmates, comparing notes, discussing conclusions, and sharing experiences are all examples of this process in action. Presentation software can help students organize their ideas and focus on important points during knowledge sharing process. Technology plays an important role in information presentation. PowerPoint (© Microsoft Corp.) is a widely used presentation programme that originated in the world of business but has now become commonplace in the world of educational technology. One of the main features of PowerPoint is that it provides structure to a presentation. This aids in the order and pacing of the presentation (Hlynka & Mason, 1998) and makes it easier for presenters to present clear summaries (Lowry, 1999). Several studies suggest that students benefit from the use of presentation graphics in the classroom (Szabo & Hastings, 2000; Atkins-Sayre, Hopkins, Mohundro, & Sayre, 1998; Mantei, 2000).

Reflection is the last cycle in the inquiry process. Galvez-Martin (1998) defines reflection as “a way of thinking about educational matters that involves the ability to make rational choices and to assume responsibility for those choices.” One of the important features that foster teachers' professional development seems to be reflective practice (Ho & Richards, 1993). Process technology assists the process of reflection. Reflection raises student teachers' awareness about teaching, enables deeper understanding, and triggers positive change. Kullman (1998) points out the awareness-raising function: “Reflection…will lead to a greater awareness among student teachers of what constitutes appropriate pedagogic practice and will lay the foundations for development, a process which will be ongoing throughout their teaching careers”. One of the common and effective reflecting practices is requiring students to write reflective reports about their experiences. Writing facilitates reflection among students, gives them the opportunity to construct and reconstruct their knowledge, and experiences (Beyer, 2001).

METHODOLOGY

The study investigates how did Inquiry-based technology enhanced collaborative learning approach contribute to student's learning experiences. In conducting this study, both quantitative and qualitative methodologies were used. This study uses Inspirations software as a tool for knowledge construction and MS PowerPoint software for information presentation as components of technology. Collaborative groups were formed to provide for cooperation between students. An inquiry cycle of "ask, investigate, create, discuss and reflect" was used. Students were asked to write reflective reports about their learning experiences. This way a technology-enhanced inquiry- based collaborative learning environment was created and established for the purpose of the study.

PARTICIPANTS

The study was conducted with two groups: Participants in the first group were freshman at Instructional and Learning Technologies Department of Sultan Qaboos University at Sultanate of Oman. Fourteen female students enrolled in TECH1101 Educational Technology: Theory and Field, an undergraduate course, participated in this study. They were between 19-21 years old. The second group was consisted of twenty one students (16 male 5 female) enrolled in TECH6101 Instructional and Information Communication Technologies, an advanced course in the Master of Education program at the College of Education, Sultan Qaboos University. 12 students were majoring in social sciences education and 9 students were majoring in science education. Their average age was 29 years.

THE DESIGN OF INQUIRY BASED LEARNING

The unit which deals with *Constructivism* has been designed according to inquiry approach in both graduate and undergraduate courses. Students were randomly paired to work collaboratively. Seven groups in undergraduate level and ten groups in graduate level were formed. Students were required to use Internet and other information resources to seek answers to research questions, create concept maps and power point presentations and write reflective reports about the topic they are searching. The students were given approximately two weeks to submit their projects.

Students' cognitive experiences have been examined through analyzing:

1. Students' concept maps of constructivism,
2. Students' presentations on constructivism,
3. Students' reflective reports on constructivism.

Students' feelings about the project, its design, and implementation were examined through analyzing students' reflections during interview.

In this study the following phases have been followed:

Ask phase. Inquiry-based learning began with the inquirers' interest in or curiosity about a topic. At this phase teacher provided students with information and background to motivate them. After discussion period students involved in determining what questions will be investigated. Seven questions (see appendix A) had been formed and distributed to whole groups.

Investigate phase. In this step the students were asked to think about the information they have and the information they want. In this phase students mainly used WWW to find and locate information that would be useful for answering the questions. Students spent considerable time exploring and thinking about the information they have found. Teacher helped students by teaching them the skills and strategies for selecting relevant information and how to compare, contrast and synthesize data.

Create phase. Organizing the information, putting the information into one's own words and creating a presentation format were the next tasks in the process. Students were asked to create concept map and electronic presentation to organize the information they had located. Inspiration (Inspiration Software Inc, 2006) was used in this study to provide a simple, easy-to-use interface for graphic generation of concepts and vectors suitable to form concept maps. The software is available on desk-top and lap-top computers allowing group work and individual work. A data projector enables whole class and group construction, discussion and evaluation of mapping. To crate electronic presentations MS Power Point was used.

Discuss phase. By using power point presentations and concept maps each group presented their work to whole class. Students shared their ideas, their own experiences and investigations to each other. Knowledge-sharing was the slogan for the process of knowledge construction. This way the students began to understand the meaning of their investigations.

Reflect phase. In order to make sense of the inquiry process, they need to understand and question the evaluation criteria, to identify the steps in their inquiry process, and to share their feelings about the process. In this phase students were asked to write reflective report on constructivism.

INSTRUMENTS

The following instruments were employed to assess students learning experiences:

Pre-post assessment. As a pre assessment, at the beginning of the study students were given blank lesson plan preparation sheets and they were asked to prepare lesson plan that incorporates principles of constructivist approach to teaching and learning. At the end of the study the blank lesson plan preparation sheets were used as a post assessment for students understanding of constructivism. Lesson plans were analyzed by researchers to evaluate student's knowledge acquisitions.

Rubric to scoring concept maps. This rubric adopted from Shaka & Bitner (1996) (see Appendix B) and used to assess students' concept maps. This rubric was four-likert type and consisted of seven subscales (prepositions, hierarchy, branches, differentiation of concepts, cross links, examples, and degree of conceptualization).

Rubric to evaluate Power Point Presentations. Iowa Slide Show Rubric was used (see Appendix C) to evaluate students' electronic presentations. This rubric was seven-Likert type and was consisted of eleven subscales (buttons and links, navigation, background, graphic sources, originality, content accuracy, sequencing of information, text-font choice, use of graphics, effectiveness, and documentation).

Rubric to evaluate students reflective reports. This rubric adopted from Asan (2003) (see Appendix D) to assess students' reflective reports. This rubric was five-Likert type and consisted of six subscales (depth of understanding, accuracy, rich supporting detail, organization, scope, and reflection)**.**

Informal Interview Questions. Four questions were formulated and asked to students to evaluate their experiences during study (see Appendix E).

FINDINGS AND DISCUSSION

SUDENTS' LESSON PLANS

Pre assessment of the lesson plans revealed that approximately 95% of the lessons created and presented by the students were not constructivist in the approach. Specifically, none of the students were able to fully implement the constructivist approach as it was envisioned by the pedagogy. Students mainly used behaviorist approaches in the design of their lesson plans. In their lesson plans objectives were behaviorist and the teacher and the textbook were the main sources of the knowledge. The role of the social interaction was missing. There was no evidence for higher level thinking and authentic activities and assessment was criterion referenced.

Post assessment of the lesson plans revealed that approximately 75% of the lessons created and presented were judged to be constructivist in approach. The questions were planned in a way that spurred student reactions. There was enough flexibility in the plan for the teacher to adjust to student responses. The learning activities engaged the students and helped them investigate the essential principle of the lesson. Authentic tasks were emphasized in meaningful context. It was apparent that in these lesson plans students used authentic resources found on the World Wide Web such as graphics and video clips. Reflected thinking shaped by instructional scaffolding provided during the planning process. They did not view assessment of student learning as separate and distinct from the classroom's normal activities but, rather, they embedded assessment directly into these recurrent activities. Their assessment procedures were including assessment of student works, observations, and points of view, as well as tests. Process was as important as product.

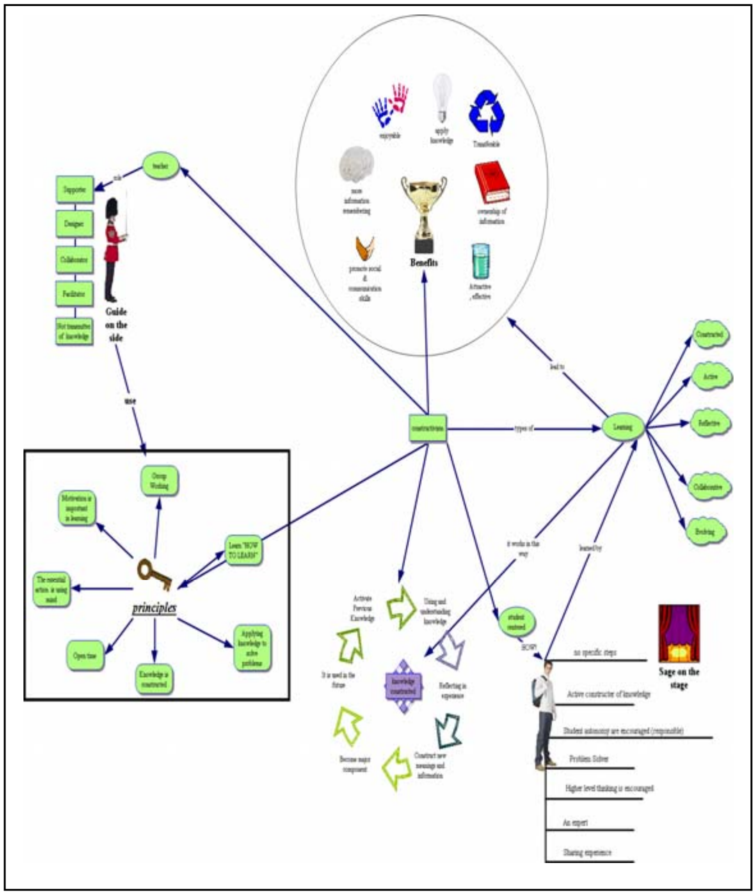

Figure 1. Concept map of constructivism by undergraduate students

STUDENTS' CONCEPT MAPS

Students were required to construct concept maps on constructivism by using Inspiration software (see Figure 1 and Figure 2 for samples). Rubric for scoring concept map was used to evaluate students' concept maps. Concept maps were assigned scores ranging from zero to four on seven subscales (prepositions, hierarchy, branches, differentiation of concepts, cross links, examples, and degree of conceptualization). The results revealed that students correctly mapped the main concepts of constructivism. Most propositions were correct (M= 2.64, SD=1.05) , most concepts and sub concepts were present and valid (M= 2.94, SD=0.65), branches were meaningful (M= 3.00, SD=0.61), sub concepts were present and non-trivial (M= 2.70, SD=0.68), cross links were valid, and there were some evidence of higher level of thinking (M= 3.05, SD=0.82), most of the examples were illustrative and significant (M= 3.17, SD=0.72), and there were evidence of clear understanding of concepts (M= 3.29, SD=0.68).

According to Independent Samples Test results that were done to examine the difference between two population means; as indicated In Table 1, all values are higher than the standard value that is 0.05 except the values of Hierarchy (0.003), Branches (0.010), Cross links (0.004), Examples (0.001), and Degree of Conceptualization (0.022) which are representing meaningful difference in qualification (graduate versus undergraduate) variable, in favor of graduate students, on the other hand other values indicate no meaningful difference between qualification based on their responds. Also to compare the magnitude of effect sizes, Cohen's d was calculated (Cohen, 1988). A statistical analysis indicated that the Cohen’s *d* values were greater than 0.8 for Hierarchy, Branches, Cross links, Examples, and Degree of Conceptualization, which is considered a significant effect. Graduate students significantly better presented main and sub concepts in their concept maps than undergraduate students. The branches, cross links and examples were appropriate and valid. Their degree of conceptualization was significantly higher than undergraduate students.

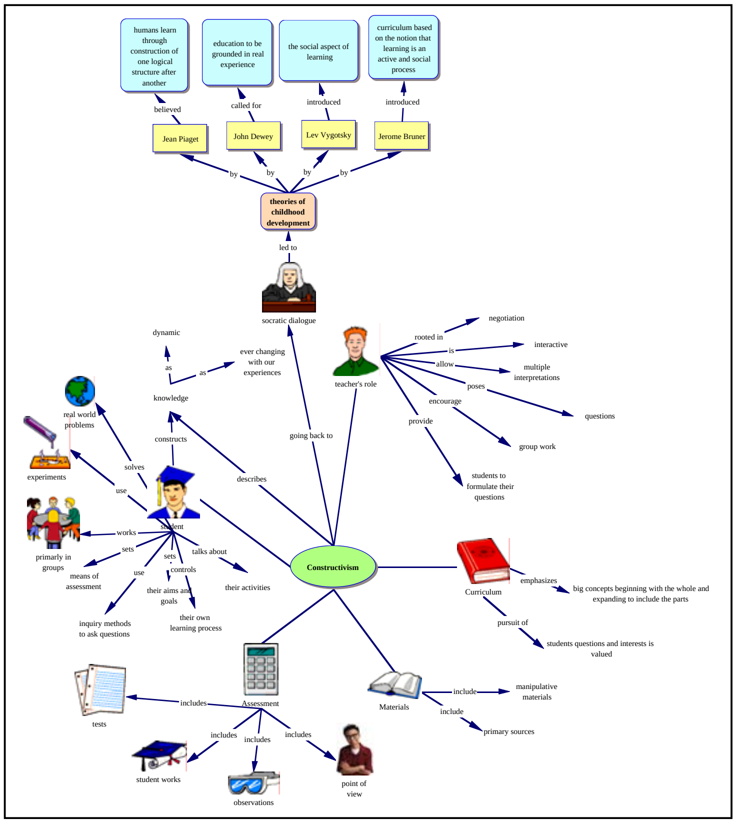

Figure 2. Concept map of constructivism by graduate students

Table 1. T-test Result: Comparison of Concept Map Scores of Graduate and Undergraduate Students.

Category	Graduate Group n=10		Undergraduate Group n=7			
	M	SD	M	SD	t	Cohen's d
Prepositions	2.5	1.17	2.85	0.89	0.674	-0.3
Hierarchy	3.30	0.48	2.42	0.53	3.507**	1.8***
Branches	3.30	0.48	2.57	0.53	2.932*	1.5***
Differentiation of concepts	2.90	0.73	2.42	0.53	1.441	0.7
Cross links	3.50	0.70	2.42	0.53	3.378**	1.5***
Examples	3.60	0.51	2.57	0.53	3.985**	2.0***
Degree of conceptualization	3.60	0.51	2.85	0.69	2.546*	1.5***

Note. * $p < 0.05$, ** $p < 0.01$, *** Cohen's d= significant size effect

Concept maps have been shown to be an effective means of representing and communicating knowledge. When concepts and linking words are carefully chosen, these maps can be useful classroom tools for observing nuances of meaning, helping students organize their thinking, and summarizing subjects of study. A growing body of research indicates that the use of concept maps can facilitate meaningful learning

(Coffey, Carnot Feltovich., Feltovich, Hoffman, Cañas, & Novak, 2003) and help students to build an organized knowledge base in a given discipline (Novak & Gowin, 1984; Jonassen, 1996). Concept maps have also been shown to be of value as a knowledge acquisition tool during the construction of expert systems (Ford, Coffey, Cañas, Andrews, & Turner, 1996), and as a means of capturing and sharing experts' knowledge (Coffey, Hoffman, Canas, & Ford, 2002). Findings from the current study support these conclusions.

STUDENTS' ELECTRONIC PRESENTATIONS

Students were required to develop electronic presentations on constructivism. Students used MS PowerPoint to create their presentations. Iowa Slide Show rubric was used to evaluate students' electronic presentations. Students' presentations were assigned scores ranging from one to seven on eleven subscales (buttons and links, navigation, background, graphic sources, originality, content accuracy, sequencing of information, text-font choice, use of graphics, effectiveness, and documentation. The results revealed that students generally were successful in presenting their findings electronically about constructivism. Most buttons and links were working correctly (M=5.11, SD=1.49), buttons were appropriately labeled (M=5.58, SD=1.54), choice of background was consistent from card to card (M=4.88, SD=1.49), a combination of hand drawn and Inspiration graphics or other clip art are used and sources were documented in the presentation for all images (M=5.23, SD=1.49), presentation showed some originality (M=4.64, SD=1.61). The content and ideas were presented in an interesting way, most of the content was accurate, most information was organized in a clear, logical way (M=5.35, SD=1.61), font formats had been carefully planned to enhance readability (M=4.88, SD=1.49), a few graphics were not attractive but all support the theme/content of the presentation (M=4.52, SD=1.50), project included most material needed to gain a comfortable understanding of the material but there was lacking one or two key elements (M=5.35, SD=1.61). Students properly documented but less than four good sources for their topics (M=4.17, SD=1.59). These results were consisted with previous research (Hlynka & Mason, 1998; Atkins-Sayre et al., 1998; Lowry, 1999; Szabo & Hastings, 2000; Mantei, 2000).

According to Independent Samples Test results that were done for qualification variable; as indicated In Table 2, all values are higher than the standard value that is 0.05 except the values of Content-Accuracy (0.006) which is representing meaningful difference in qualifications variable in favor of graduate students, on the other hand other values indicate no meaningful difference between qualifications based on their responds. Cohen's *d* calculation for effect size indicated that the values were greater than 0.8 only for Content-Accuracy. Graduate students presented more correct content in their presentations than undergraduate students.

STUDENTS' REFLECTIVE REPORTS

Students were required to write reflective reports on constructivism. Their written reports were evaluated by using rubric for evaluating reflective reports. Students' reflective reports were assigned scores ranging from one to five on six subscales (depth of understanding, accuracy, rich supporting detail, organization, scope, and reflection). Results revealed that students' reflective reports were clear (Mean=3.41, SD=0.80), content and vocabulary were accurate (Mean=3.82, SD=0.88), ideas were excellently interpreted (M=3.71, SD=0.77), ideas were highlighted, well organized (M=3.59, SD=0.71), focused and specific (M=3.64, SD=0.78), and thoughts were reflective and well represented (M=3.80, SD=0.80).

According to Independent Samples Test results that were done for qualification; as indicated In Table 3, all values are higher than the standard value that is 0.05 except the values of Accuracy (0.000), Scope (0.021), and Reflection (0.005) which is representing meaningful difference between qualifications variable in favor of graduate students, on the other hand other values indicate no meaningful difference between qualifications based on their responds. Also Cohen’s *d* values were greater than 0.8 for Accuracy, Scope and Reflection, which is considered a significant effect.

Table 2. T-test Result: Comparison of Power Point Scores of Graduate and Undergraduate Students.

Category	Graduate Group n=10		Undergraduate Group n=7			
	M	SD	M	SD	t	Cohen's d
Buttons and Links Work Correctly	5.20	1.751	6.142	1.069	1.262	-0.62
Buttons -Navigation	5.20	1.751	5.000	1.154	0.263	0.13
Background	5.40	1.577	4.142	4.142	1.827	0.44
Graphics Sources	5.40	1.264	5.000	1.632	0.570	0.28
Originality	4.40	1.646	5.000	1.632	0.722	-0.37
Content -Accuracy	6.40	1.349	4.142	1.573	3.173**	1.57***
Sequencing of Information	5.80	1.686	4.714	1.380	1.402	0.69
Text – Font Choice & Sequencing	5.40	1.577	4.142	1.069	1.827	0.77
Use of Graphics	4.60	1.577	4.428	1.511	0.224	0.11
Effectiveness	5.80	1.686	4.714	1.380	1.402	0.63
Documentation	4.60	1.837	3.571	0.975	1.345	0.54

Note. * p= 0.05, **p= 0.01, *** Cohen's d= significant size effect

Table 3. T-test Result: Comparison of Reflective Report Scores of Graduate and Udergraduate Sudents.

Category	Graduate n=21		Undergraduate n=14			
	M	SD	M	SD	t	Cohen's d
Depth of Understanding	3.70	0.67	3.00	0.81	1.933	0.7
Accuracy	4.40	0.51	3.00	0.57	5.245**	2.7***
Rich Supporting Detail	4.00	0.66	3.58	0.75	2.060	0.62
Organization	3.80	0.78	3.28	0.48	1.525	0.77
Scope	4.00	0.66	3.14	0.69	2.572*	1.32***
Reflection	4.20	0.78	3.14	0.37	3.270**	1.68***

Note. * p= 0.05, **p= 0.01, *** Cohen's d= significant size effect

Rosier (2002) indicated that reflection after the event is an important part of the learning process. Requiring students to write brief reflective reports, after the class discussion of a case, has been used successfully to improve student learning and to improve the perceived value and relevance of a case study. In addition, he concluded that the use of reflective reports does a great deal to overcome concerns about value and relevance in management education. Findings from the current study support these conclusions.

STUDENTS' FEELINGS ABOUT THE MATERIAL, ITS DESIGN AND IMPLEMENTATION

Active involvement in the process. Analysis of student interviews revealed that students believed that they learned better when they were presented with intrinsically motivating questions and were provided the support and encouragement to discover relevant knowledge about those questions. Students reported that they actively collected, analyzed, and synthesized the information, and drew the conclusions. As students pointed out:

- This way of learning was superior to learning in the traditional format. The reason for this is obvious. I was involved in the learning process on a daily basis.
- Another student stated: My learning is facilitated by trying to solve questions about the content, discussing it, and most of all presenting it.
- Another student stated: It is good to start by questions. You get motivated and try to find answers to questions.
- Another student stated: I felt that I am responsible for my own learning**.** I don't like memorization. I like practical applications. You can be active and you can learn more. But in this class, I learned how one can learn without memorizing.
- Another student stated: This activity required us to actively participate in learning since we were working with the computer and software. We learned constructivism at the same time there was an opportunity to build hands-on skills through active learning.

These results are consistent with the findings of many other studies (Chiappetta & Russel, 1982; Saunders & Shepardson, 1987; Haury, 1993; Paris & Paris, 2001; Patrick & Middleton, 2002; Perry, et al, 2002). They confirmed that inquiry-based activities create situations for students to be self-regulated and independent learners and students learn much more when they are given inquiry based learning environments to first experiment on specific information relevant to a topic.

Using technology both in acquiring information and communicating results. Analysis of student interviews revealed that student believed that their learning was enhanced by using technology. Students mainly used Internet as information search tool in the context of a larger goal, so that deciding which resources to use, how to find them, and what information to extract are all related to a project. Students also used Inspiration software to develop concept maps about the content they are studying and they have also used PowerPoint to present their findings. One student indicated that:

- I think the Internet is a good learning tool. You can find the information you need fast and easily. We used Internet more than library. The Internet had a positive impact on my learning.
- Another student stated: Internet is full of materials about constructivism. Many thousands of sites are coming up containing articles, presentations about constructivism. Our problem was deciding on what to select among millions of sites. It was amazing. We located very useful sites. We downloaded most of them and then tried to select best sites.
- Another student stated: We used the AltaVista and Google Search engine to conduct a search for specific phrases. To search for an exact match, we used quotation marks around the string. If quotations marks are not used, the results will include Web pages that contain some or all of the words in the string.
- Another student stated: Inspiration! It is easy way to create concept maps. Before it was difficult to create concept maps. Now it is really easy.
- Another student stated: We used inspiration and later MS PowerPoint to create effective presentations. This helped us to analyze content more depth.

These findings are consistent with the results of other research (Fisher, et al., 1990; Pea, 1985; Becker & Riel, 2000). They indicated that technology is a powerful tool in building constructivist learning environments.

Collaborative working. Majority of students believed that group work facilitated their learning. As one student pointed out:

- For me the collaborative work has been very productive, I have learned very much from my team-mates, they teach me a new way to see team work, new ways to work.
- Another student stated: I think this way of learning has been really useful; this is because we help each other to understand topics like constructivism and how it is different from traditional approach.
- Another student stated: The presentations were very interesting because it is easier for us to understand other students when explaining difficult topics like constructing knowledge, teacher role, and student role. I hope this kind of activities to continue along the semester.
- Another student stated: I believe up to this day, this class has been the only one that really makes me feel that I am at the University. I don't find much interest in these same old-fashioned systems of education. I think that collaborative working provides us several opportunities.

These results are consistent with the findings from other studies (Scardamalia & Bereiter, 1994; Koschmann, 1996; Koschmann, et al., 2001). They confirmed that computer supported collaborative environments has a positive effect on students learning experiences.

Providing opportunities for reflection. Analysis of student interviews showed that each participant found reflecting helpful. As one student reported that:

There were multiple opportunities for reflection. First we discussed how this approach is different than behaviorism. Later on we presented our concept maps. All maps were different from each other. We corrected our misconceptions. I benefited from discussing ideas with other students.

- Another student stated: During our presentation our classmates asked questions that made us think more on reasons and evidences. It has deepened my understanding about the constructivism.
- Another student stated: Peer-group work allowed me to see other points of view. It made me more eager to participate because I see the possibility for change and action.
- Another student stated: You are not only listening to what your instructor says. You are participating and reflecting your thoughts on the topic. This method of learning should be applied in every university level courses.

These findings provide empirical support for claims made by other researchers about the nature of inquiry based learning which provides deeper-level cognitive strategies such as monitoring, creating representations, reflecting and sharing information collaboratively (Salovaara, 2005).

CONCLUSION

This study showed that well designed an inquiry-based technology enhanced collaborative learning environment can enhance students learning experiences. The results were consistent with the previous research (Bereiter & Scardamalia, 1993; Dede 1998; Chang, et al., 2003). The unique contribution of this study is that this method of learning is valuable for both graduate and undergraduate level students. Undergraduate students' performances were nearly close to graduate students' performances in the same unit of the study. The most productive and worthwhile inquiry based activities in this study requires students to gather data but go beyond simply reporting the findings. When the students were asked to analyze their findings then they compared, contrasted and reflected on them a more sophisticated level of knowledge develops. When they related them to their personal experiences they advanced their knowledge. When they were asked to create or construct some of original knowledge then their educational experiences become true constructivist ones. These results are particularly exciting because they cast a whole new light on the issue of designing inquiry-based learning environments for university courses in general, and enhancing this method by using technology and collaboration in particular.

In the well designed inquiry-based learning the learner asks questions. These questions lead to the desire for answers to the question and result in the beginning of exploration and hypotheses creation. These hypotheses lead to an investigation to test the hypothesis or find answers and solutions to the question and/or problem. Students mainly use Internet sources during investigation. The investigation leads to the creation or construction of new knowledge based on investigation findings. Students work collaboratively and they use technology in the knowledge creation process. The learner discusses and reflects on this newly-acquired knowledge, which, in turn leads to more questions and investigations that lead to conclusion.

Overall, this study found evidence that an inquiry-based technology enhanced collaborative learning can help students acquire and flexibly use complex knowledge. We view the results of this study related to designing inquiry-based technology enhanced collaborative learning environment as encouraging, but provisional and in need of further research. However, we feel that these results are educationally significant and the methodology we are using will continue to be useful in identifying important factors associated with learning in inquiry-based technology enhanced collaborative learning environments. There is certainly much more work to be done.

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Appendix A
QUESTIONS WERE USED IN "ASK" CYCLE

1. How does constructivism shape teaching-learning process? Do you think such potentially unstructured, open-ended strategies work in real classroom situations?
2. What are the most effective ways of planning teaching-learning activities that give students more freedom and responsibility in learning process?
3. Do you believe that constructivist teaching methods are appropriate for all students? If your answer is ”No” , might some students benefit more from those methods while others do better with instructive methods ? How would you characterize the type of students in each group?
4. Do some subjects (contents) lend themselves to more constructivist method than others? If so, give and discuss the reasons.
5. You have spent years in various educational institutions as a student. Have you ever had a teacher who used constructivist teaching methods? How did those experiences differ from more traditional ones? Which did you think were more successful? Which were more enjoyable?
6. We might not have to choose either constructivist or instructivist teaching methods. Instead, we might see teaching strategies as lying on a continuum between the two extremes. If this is so, maybe different strategies are most appropriate for different situations, subject matters, and audiences. Discuss this possibility and how you might put it into practice.
7. Perhaps even more difficult than reconciling the idea of “planning” with that of “constructivism” is the problem of reconciling the fact that government has prescribed curricula. How can you plan lessons that teach a given curriculum and still use genuinely constructivist methods?

Appendix B
RUBRIC TO EVALUATE CONCEPT MAPS

	4	3	2	1	0
Prepositions	Complete, meaningful and valid	Most are meaningful and valid	Some are meaningful and valid	Incomplete few are meaningful and valid	Missing or not meaningful
Hierarchy	Main and subordinate concepts are present and valid	Most but not all concepts are present and valid	Some are present and valid	Few are present and valid/several subordinate concepts are missing	Hierarchy is missing or invalid
Branches	All are appropriate, meaningful and valid	Most are appropriate, meaningful and valid	Some are appropriate, meaningful and valid	Few are appropriate, meaningful and valid	Missing, inappropriate or invalid
Differentiation of concepts	All valid ,subconcepts are present	Most of the valid, subconcepts are present	Some of the valid, subconcepts are present, some subconcepts are invalid or trivial	Few of the valid, subconcepts are present, most subconcepts are invalid or trivial	Valid subconcepts are missing or subconcepts are invalid
Cross links	All are valid and non-trivial. Strong evidence of higher level of thinking	Most are valid and non-trivial. Some evidence of higher level of thinking	Some valid but trivial. Some evidence of higher level of thinking	Most are invalid and trivial. Little evidence of higher level of thinking	Missing or invalid. No evidence of higher level of thinking
Examples	Complete set; valid; illustrative and significant	Incomplete set; but most are present and valid; illustrative and significant	Incomplete set; but some are present and valid; illustrative and significant	Incomplete set; but few are present and valid; illustrative and significant	Missing or invalid
Degree of conceptualization	Evidence of clear understanding of concepts	High degree but not complete understanding of concepts	Moderate degree of understanding of concepts. Some naïve or faulty conceptions	Low degree of understanding of concepts. Several naïve or faulty conceptions	No evidence of understanding concepts.

Appendix C
RUBRIC TO EVALUATE POWER POINT PRESENTATIONS

Category	7 pts	5 pts	3 pts	1 pt
Buttons and Links Work Correctly	All buttons and links work correctly.	Most (99-90%) buttons and links work correctly.	Many (89-75%) buttons and links work correctly.	Fewer than 75% of the buttons work correctly.
Buttons - Navigation	Buttons are appropriately labeled and all similar buttons (e.g. Back, Home, Next, etc.) appear in the same place on different cards.	Buttons are appropriately labeled. Most similar buttons (e.g. Back, Home, Next, etc.) appear in the same place on different cards.	Buttons are appropriately labeled. Placement of buttons appears random from card to card.	Buttons are not adequately labeled and placement of buttons appears random from card to card.
Background	Background does not detract from text or other graphics. Choice of background is consistent from card to card and is appropriate for the topic.	Background does not detract from text or other graphics. Choice of background is consistent from card to card.	Background does not detract from text or other graphics.	Background makes it difficult to see text or competes with other graphics on the page.
Graphics Sources	Graphics are hand-drawn. the Illustrator (s) are given credit somewhere in the presentation.	A combination of hand drawn and Hyper Studio graphics or other clip art are used. Sources are documented in the presentation for all images.	Some graphics are from sources that clearly state that non-commercial use is allowed without written permission. Sources are documented in the presentation for all "borrowed" images.	Some graphics are borrowed from sites that do not have copyright statements or do not state that non-commercial use is allowed, OR sources are not documented for all images.
Originality	Presentation shows considerable originality and inventiveness. The content and ideas are presented in a unique and interesting way.	Presentation shows some originality and inventiveness. The content and ideas are presented in an interesting way.	Presentation shows an attempt at originality and inventiveness on 1-2 cards.	Presentation is rehash of other people's ideas and/or graphics and shows very little attempt at original thought.
Content - Accuracy	All content throughout the presentation is accurate. There are no factual errors.	Most of the content is accurate but there is one piece of information that might be inaccurate.	The content is generally accurate, but one piece of information is clearly flawed or inaccurate.	Content is typically confusing or contains more than one error.
Sequencing of Information	Information is organized in a clear, logical way. It is easy to anticipate the type of material that might be on the next card.	Most information is organized in a clear, logical way. One card or item seems out of place.	Some information is logically sequenced. An occasional card or item of information seems out of place.	there is no clear plan for the organization of information.
Text - Font Choice & Sequencing	Font formats (e.g., color, bold, italic) have been carefully planned to enhance readability and	Font formats have been carefully planned to enhance readability.	Font formatting has been carefully planned to complement readability and	Font formatting makes it very difficult to read the material.

	content.		content. It may be a little hard to read.	
Use of Graphics	All graphics are attractive (size and colors) and support the theme/content of the presentation.	A few graphics are not attractive but all support the theme/content of the presentation.	All graphics are attractive but a few do not seem to support the theme/content of the presentation.	Several graphics are unattractive AND detract from the content of the presentation.
Effectiveness	Project includes all material needed to gain a comfortable understanding of the topic. It is a highly effective study guide.	Project includes most material needed to gain a comfortable understanding of the material but is lacking one or two key elements. It is an adequate study guide.	Project is missing more than two key elements. It would make an incomplete study guide.	Project is lacking several key elements and has inaccuracies that make it a poor study guide
Documentation	You have properly documented 4 or more good sources for your topic.	You have properly documented less than 4 good sources for your topic.	You have properly documented less than 4 sources for your topic, some of which are weak.	You have not properly documented the sources for your topic and the sources are too few or inappropriate

Appendix D
RUBRIC TO EVALUATE REFLECTIVE REPORTS

Depth of Understanding				
1	2	3	4	5
Overall purpose unclear Ideas unclear No depth				Consistent overall purpose Clear overall ideas Depth of understanding
Accuracy				
1	2	3	4	5
Misuse of vocabulary Lack of data Irrelevant information				Correct use of vocabulary Strong on reality, high validity, reliability Relevant information
Rich Supporting Detail				
1	2	3	4	5
Little supporting detail Poor interpretation of ideas Simplistic analysis				Rich supporting detail Excellent interpretation of ideas Specific aspects are recorded
Organization				
1	2	3	4	5
Poor organized Unclear of simplistic paper structure Unclear key points				Well organized Tight paper structure Key points are highlighted
Scope				
1	2	3	4	5
Poor focused, unspecific Leave out key ideas and information Difficult to visualize experience				Focused, specific Draws a picture of the theory Reader can visualize experience
Reflection				
1	2	3	4	5
Idea is common place Ideas barely represented His/her thoughts are not recorded				Idea is reflective Ideas well represented His/her thoughts are recorded

Appendix E
INTERVIEW QUESTIONS

1. In which cycle of inquiry based learning did you have difficulty?
    - ask
    - investigate
    - create
    - discuss
    - reflect
2. What TWO things did you most enjoy about this learning approach?
3. What did NOT you enjoy about this learning approach?
4. Do you think that you want to use this approach when you start teaching professionally?