A CASE OF WEB-BASED INQUIRY LEARNING MODEL USING LEARNING OBJECTS

Al Musawi, A. (asmusawi@squ.edu.om)
Asan, A. (askinasan@hotmail.com)
Abdelraheem, A. (ahmedyar@squ.edu.om)
Osman, M. (mosman@squ.edu.om)

Instructional and Learning Technologies Dept., COE, Sultan Qaboos University, Oman

ABSTRACT
This research seeks to (1) implement a model for an inquiry based learning environment using learning objects (LOs), and (2) apply the model to examine its impact on students' learning. This research showed that a well-designed learning environment can enhance students learning experiences. The proposed model was applied to an undergraduate course offered by the Faculty of Education, Sultan Qaboos University, in 2009. Results indicate that the implementation of the web-based inquiry-learning model was successful and adequate to the learning setting. This model of learning helped most students to manage the tools and techniques used during the course; freedom on the construction of presentations allowed students to explore creatively the subject domain; independent learning together with presentations contributed to preserve the uniqueness and value of each student's production. Finally, the open educational resources used as support were of fundamental importance.

INTRODUCTION

The learning object (LO) concept is stimulating so much interest, research and investment currently. The need arises from the arrival of the "knowledge economy", where lifelong learning is vital to individual and national success, and knowledge is proliferating and changing at an unprecedented rate. The main idea of LOs is to break educational content down into small chunks which can be reused in various learning environments, in the spirit of object-oriented programming. LOs present the information, provide the student with an infinite amount of practice, and provide a test that allows the computer to provide feedback. Our view of LOs fits Wiley's definition, "any digital resource that can be reused to support learning" (Wiley, 2000). The "materials" in a learning object can be documents, pictures, simulations, movies, sounds, and so on. They are digital in nature. These LOs can be delivered or accessed over the Internet or across a network. LOs can also include metadata, which is information about the learning object itself (Johnson, 2003).

LOs open up possibilities that traditional materials may not offer. Within a single learning object, information can be presented in several different ways, allowing students to explore a topic from various perspectives responding to their individual needs and learning styles. Engaging interactive elements give learners a chance to practice what they are studying.

Three most compelling reasons for using LOs are that they are flexible, they are cost effective, and they can be combined in customized ways (Smith, 2004):

> *Flexibility*: A well-designed learning object — or a combination of several that deal with the same topic — can offer access to knowledge through multiple modes of learning. Students who learn particularly well by auditory means, for example, may find an interactive learning object with voiceover instruction to be effective.
> *Cost effectiveness*: As non-consumable resources, LOs can be used in a course from one semester to the next. Some can be repurposed for different courses or even different disciplines. Many are available free of charge.
> *Customizability*: Lecturers may select LOs to suit their course material and particular instructional style. With a minimum of online research, faculty can assemble an array of ready-made support materials to offer their students.

Individual LOs can be designed to present a complete learning experience. LOs can offer interesting new possibilities to implement constructivist learning environments and engage learners with meaningful learning activities. However, although LOs can provide stimulating opportunities to improve educational practices, to extend the use of digital technologies in schools and to reduce the time required to prepare technology enhanced teaching, many associated problems and practical shortcomings can arise (Li, et al., 2006; Akpinar & Simsek, 2007; Kay & Knaack, 2007). The LO approach holds tremendous promises but also considerable problems. The problem of LOs is the same than with every new educational technology innovation. They offer novelty,

economic benefits and motivating potential that can, if used carelessly, lead to flawed teaching and learning practices that are ignoring the true essence of human learning.

The detractors of the LOs approach say it is a "dumbing-down" of the learning process and they claim that the LOs focus on content rather than discussion or dialogue in the learning process (Mason, et al., 2005). Learning object research has also addressed instructional design issues such as the model of behavioristic-content learning is largely presented, students are asked questions, and then evaluated and rewarded based on the content they remember (Krauss & Ally, 2005). Within the last ten years, several learning object theorists have advocated the use of more constructivist-based metric (Kay & Knaack, 2009).

LOs themselves are not good or bad, but their pedagogical value is determined through the context of use. Implementation of LOs needs a sound pedagogical grounding, and only using LOs according to the principles of contemporary learning theories can LOs fulfill those promises (Nurmi & Jaakkola, 2006). It is important to remember that LOs and their content is not knowledge, but just means to engage learners and give rise to various learning processes and experiences. The content of the LOs can only be regarded as information – as raw material from which one can construct meaningful and mindful subjective knowledge structures (Sveiby, 1997).

The current movement in education today calls for students to develop information age skills rather than build content bases. Critical thinking, problem solving skills, and communication skills are more important than simply knowing the content itself. In response to these calls there are many varieties of inquiry-based, constructivist learning environments being developed. The inquiry approach is more focused on using learning content as a means to construct knowledge and develop critical thinking skills. Meanwhile, learning has moved towards more student-centered, problem-based, challenge-based, or cooperative learning.

Inquiry Based Learning is a pedagogy that engages students in finding solutions to important and meaningful questions through investigation and collaboration with others (Blumenfeld, et al., 1991). Well-designed inquiry-based learning environments can enhance students learning experiences (Bereiter & Scardamalia, 1993; Dede, 1998; Chang, et al., 2003). Blumberg (2000) argues that inquiry can nurture critical thinking and information processing skills. He states that inquiry tends to improve students' self-regulated learning abilities. Through such an approach, students acquire an understanding of key principles and concepts, develop important habits of mind, and learn to communicate their knowledge to others (Brown & Champione, 1995). Discussion forums have been used for educational purposes as a tool for promoting different modes of learning that can lead to enhanced learning outcomes for students (Montero, et al., 2007).

In practice, an inquiry-based learning environment supports the development of understanding in many ways. The environment should be based around an authentic problem that provides a motivating context for learning. These problems should be open-ended, allowing students to tackle situations in authentic ways to solve a problem with no one right answer. The inquiry-based learning environment should allow for social negotiation so students can test their understandings against others' and readily share information. Finally, the environment should be designed to help students construct knowledge. This is supported by the social negotiation and through the context, but also depends on modeling and scaffolding to help students become successful learners as well as provide them with opportunities for reflection (Jonassen, 1999). Inquiry Based Learning is often described as a cycle or a spiral, which involves formulation of a question, investigation, creation of a solution or an appropriate response, discussion, and reflection in connection with results (Bishop et al., 2004). Research suggests that using inquiry-based learning can help students develop critical thinking skills, become more creative, more positive and more independent (Kühne, 1995). Other academic research shows that inquiry-based learning improves student achievement (GLEF, 2001).

The dissemination of Internet technologies in recent years has fostered the development of technology enhanced inquiry-based learning models. For example, Chang, Sung and Lee (2003) proposed a web-based collaborative inquiry-learning model where students used: the web as information source; concept mapping software as a tool for anchoring and representing knowledge during the inquiry process; notepads to help compile, edit and share information; and chat sessions for synchronous group discussions. Abdelraheem and Asan (2006) used concept-mapping software, web search, and MS PowerPoint as tools for students to create their maps and class presentations. In order to assess students' learning experiences, these authors employed pre-post assessments, rubrics and informal interviews to evaluate students´ concept maps, presentations, and self-reflective reports. Tractenberg, Struchiner, and Okada (2009) presented a case study of web-based collaborative inquiry-learning using OpenLearn technologies. They adopted a web-based collaborative inquiry learning model supported by UK Open University's OpenLearn technologies: a community-led virtual learning environment based on

Moodle called *LabSpace*, and a knowledge mapping software called *Compendium*. Their results indicated that the implementation of the web-based inquiry-learning model they have proposed was relatively successful and adequate to the learning setting. These three studies pointed out the benefits of integrating collaboration and inquiry as pedagogical strategies supported by appropriate technologies.

This study describes the application of inquiry based learning theory to the use of LOs and how doing so can help learners achieve outcome goals. In inquiry-based learning environments as in others, students need access to good content, ways of measuring their understanding, and the ability to have multiple exposure opportunities when confronted with new information. Because of these needs, LOs seem to provide an excellent support tool in these inquiry-based learning environments.

THE CASE STUDY

Instructional and Learning Technologies Department at the College of Education of Sultan Qaboos University has been offering a course entitled: "Introduction to Educational Technology" (TECH3008) as a service course to all departments of the College of Education. This course involves information about the role of information technologies and resources in instruction, with emphasis on computer applications' software and utilization of materials in schools. Students in this course explore the basic components of the instructional development process and the instructional methods by which instruction is delivered. They identify and apply the major terms and theories underlying the design of instructional materials and they learn how to review, evaluate, and develop technology-based instructional materials.

However, there are important issues confronting faculty when teaching this service course such as developing and using quality content, standardization, sharing and exchanging of learning materials, and creating effective environments where students are active learners, sharing and discussing their ideas, constructing their own knowledge and developing critical thinking skills. To face this challenge, 'Introduction to Educational Technology' is modified for delivery in hybrid mode and the authors decided to develop LOs to support learning.

The authors anticipated that LOs would not only help faculty deliver high-quality, sharable, and reusable learning materials but also have a positive effect on students' learning especially when used in an inquiry based learning environment.

For the pilot study, the project team selected the 'Basic Principles of Visual Design' unit from the course content. The content of the unit is constructed of 20 LOs presented over five phases. The unit was taught four weeks. The format of instruction for the unit was fully online.

The 'Basic Principles of Visual Design` unit introduces the visual communication principles and concepts of successful visual design. Topics include form, color palettes, text and image relationships, typography, grid structures, and layout design.

A part-time specialized multimedia designer was hired and a cutting-edge computer workstation was bought to produce the LOs. The project team members convened with the designer on a continuous basis to provide formative feedback on both the technical and instructional design of the objects.

Each object is autonomous so that it can be re-used, removed or altered with relatively little consequence for the remaining objects. Each object is sufficiently rich and complex to achieve a specific learning outcome.

Each learning object contained the essential components of an effective learning experience such as a discursive element (the key issues and follow up readings), an interactive element (group or individual activity or online discussion), an experiential element (the activity) and a reflective element (choice of readings and level of engagement).

The objects were validated by reviews of an academic expert in Educational Technology. Final modifications were then made and were set for upload on the Moodle system. Moodle is a free Learning Management System (LMS) that educators can use to create effective online learning sites. LMSs are widely used for distance education, but can also be effectively used for blended or hybrid education, where they offer a complementary role to traditional classroom instruction.

Moodle is grounded in a philosophy of collaborative learning, often referred to as social constructionist pedagogy. This approach views learning as a creative social process, as much as it is an individual one, where

people learn together by investigating, analyzing, collaborating, sharing, and reflecting. Moodle provides a suite of tools to promote interaction and social networking among people, so that they can share ideas, collaborate in small groups, discuss, and reflect upon experiences. By presenting LOs with the communication tools of Moodle and applying inquiry based learning, the researchers anticipated to overcome limitations of LOs use in learning.

Spiral path of inquiry has been used when designing the unit activities: asking questions, investigating solutions, creating new knowledge, discussing discoveries and experiences, and reflecting on new-found knowledge. The evaluation process incorporated a number of methods to provide field data.

As an organizing framework, a social format was chosen, which is less formal and more discussion- focused. LOs are placed in five phases in social format of Moodle:

1. Ask phase: Inquiry-based learning began with the inquirers' interest in or curiosity about a topic. Four LOs were used in this phase. LOs were designed to provide students with background information about the visual design. Through LOs several questions were presented to the students to initiate the thinking process among them. Moodle's communication tools such as chat, discussion and dialogue were included in this phase. After a discussion period, students were asked to determine what questions will be investigated such as 'How are visual design principles and elements used to capture a learner's attention? 'How are visual design principles and elements utilized in a design?', and 'What are the main elements used in web design?'
2. Investigate phase: In this phase twelve LOs were used. Through LOs, each principle of visual design was explained and useful references and related internet sites were presented to students. Students mainly used the Internet to find and locate information that would be useful for answering the questions that they have determined in the first phase. Some off-line and online resources were available to the students to find and locate information. By using Moodle's communication tools, students had opportunities to discuss, compare and contrast the information and data that they had located. Also by including Moodle's evaluation tools, students were able to test their own knowledge.
3. Create phase: Four LOs were used in this phase. Learners were introduced with guided activity to create digital instructional material for K12 students. Organizing the information, putting the information into one's own words and creating a presentation format were the next tasks in the process. After finishing the guided activity, students were asked to create PowerPoint presentations about the topic of their interest and apply visual design principles to their presentations. After designing their own digital presentations, they have uploaded their work into Moodle environment by using its assignment module.
4. Discuss phase: By using Moodle's assignment module students presented their final product to their classmates. In this phase, students shared their ideas and their own experiences and investigations to each other. Knowledge-sharing was the slogan for the process of knowledge construction. In this way, students began to understand the meaning of their investigations.
5. 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 their own learning process.

RESEARCH METHODOLOGY

Instruments

How well did this theoretical model work in practice? The impact on student learning and study processes was researched through the following three forms of data collection:

1. Students evaluation of LOs were analyzed by using Learning Object Evaluation Sheet (Alpha=0.77) (see Appendix A).
2. Students were interviewed by researchers to identify their opinions regarding to the inquiry based learning approach and their comments transcribed and compared. Four questions were formulated and asked to students to evaluate their experiences during study (see Appendix B).
3. Student's Power Point presentations were evaluated. Iowa Slide Show Rubric was used (see Appendix C) to evaluate students' Power Point 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).

Sample
The sample was purposive since it includes all (44) students enrolled in the course entitled: "Introduction to Educational Technology" during the summer semester 2009 as listed by the Students' Registration Deanship.

Impact on Student Learning
1. Evaluations of learning objects by students

All of the students in the 'Introduction to Educational Technology' course have evaluated the LOs that have been used in the study of the unit.

The results of their evaluation provided important data related to the students' use of the LOs. Students indicated that LOs loaded quickly (94% of students), LOs were professional looking (81% of students), LOs were easy to use (85% of students), there was NOT too much reading required (52% of students), graphics/animations assisted learning (71% of students), LOs had good interactivity (80% of students), and feedback from interactions were clear and helpful (81% of students).

2. Students' opinions regarding the inquiry based learning approach
Cycles of inquiry based learning: Students generally found all the cycles of inquiry based learning to be very useful to discover their abilities and skills. However, most of them commented that they found the "discussion" the most difficult phase of the cycle. Positive comments about the inquiry based learning focused on relevance and understanding. Students repeatedly commented on their newfound abilities as learners and their ability to apply their knowledge to the real-world.

Strengths: The students mostly enjoyed the following about the theoretical model:

1. Learning objects
2. Learning independently without being forced to.
3. Creating their own media and using them.
4. Sharing information and experiences.
5. Thinking deeply to find creative ideas.

Here are some examples of their opinions:
'LOs were very helpful to understand the topic. They also included very useful links to search about the complicated topics'
'With the use of LOs I was able to learn by myself without receiving any help from teacher'
'I was responsible from my own learning and we learned without being forced to'.
'We asked many questions at the beginning and those questions lead us to activities and later on we developed our own materials'
'There were many discussions but finally we found creative ideas for our presentations'.
'It was difficult at the beginning but later on I found it very rewarding'
'I selected and used the material that I need. I discussed with my classmates and teacher about my observations and questions'
'We looked forward to learning and had to demonstrate more desire to learn more. Working cooperatively with other students was useful.'
'I feel more confident in learning'.
'We expressed our ideas in a variety of ways, including chat, discussion, journal and so forth'.
'We assessed our own work and other classmates, we reflected on our own learning'
'I reflected on my own learning and I reported my strengths and weaknesses'.

Weaknesses: The students did NOT enjoy the following about the theoretical model:
1. Lack of tutor's assistance to answer their questions.
2. Feeling shy to share information with other colleagues.
Here are some examples of their opinions:
'The instruction for the unit was totally online. I usually get motivated when real teacher is involved'
'It was difficult because the work requires one to arrive at resolutions to problems by brainstorming with other students'
'Sometimes I was unable to complete meaningful investigation. I also felt shy during chatting with my classmates and in discussion and tried to hide it'.

Prospective implementation: When asked if they will integrate this approach in their future teaching, their responses were generally positive. Here are some examples of their opinions:
"I will, but with some active instructor role on it as a facilitator to improve it"

"Of course, I will apply and use this learning approach in my teaching and I will also try to teach the topics that I learned in this course."
"Yes, but not all the time or all subjects, it depends on the subject and background which students have."
"It depends on the time, if there is enough time"

3. Evaluations of Power Point Presentations
Students were asked to create PowerPoint presentations about the topic of their interest and apply visual design principles to their presentations. All Power Point presentations were analyzed by the research team and scored according to the relevant rubric (see appendix C).

Iowa Slide Show rubric was used to evaluate students' 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 applying visual design principles to their presentations. Most buttons and links were working correctly (M=4.11, SD=1.4), buttons were appropriately labeled (M=4.58, SD=1.53), choice of background was consistent from card to card (M=5.78, SD=1.39), a combination of hand drawn and graphics or other animated clip art are used and sources were documented in the presentation for all images (M=6.34, SD=1.69), presentation showed some originality (M=4.83, SD=1.51). 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=4.85, SD=1.56), font formats had been carefully planned to enhance readability (M=5.88, SD=1.72), a few graphics were not attractive but all support the theme/content of the presentation (M=5.11, SD=1.67), project included most material needed to gain a comfortable understanding of the material but there was lacking one or two key elements (M=5.46, SD=1.72). Students properly documented but less than four good sources for their topics (M=5.18, SD=1.46).

CONCLUSION
This study showed that a well-designed learning environment can enhance students learning experiences. Scores point to achievement of students' presentations, and reports on students' satisfaction with different aspects of the course were quite positive. 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 LOs in particular.

The results of the study were consistent with the previous research on inquiry based learning and LOs. Previous research indicates that engaging in inquiry can improve students' learning in their disciplines (Blumenfeld, et al., 1991; Bereiter & Scardamalia, 1993; Brown & Champione, 1995; Dede 1998; Blumenfeld, et al., 2000; Krajcik, et al., 2001; Chang, et al., 2003; Brickman, et al., 2009**;** Abdelraheem & Asan, 2006; Montero, et al., 2007; Yasar & Duban, 2009; Tractenberg, et al., 2009). Learning through inquiry will increase students' ability to apply what they learn to new situations. Blumberg (2000) argues that inquiry can nurture critical thinking and information-processing skills. He finds that inquiry tends to improve students' self-regulated learning abilities. In short, inquiry-based learning enables students to be more reflective, self-regulated investigators who are capable of justifying their own learning processes and viewing inquiry process as a way to know the world (Windschitl, 2000). Inquiry based learning was perceived to develop students' thinking skills, and enable students to become more creative, more positive and more independent (Kühne 1995). These types of research results support the idea that inquiry-based learning is a valuable method for educational researchers and practitioners.

For students to engage in inquiry in a way that can contribute to meaningful learning they must be sufficiently motivated. When students are not sufficiently motivated or they are not motivated by legitimate interest, they either fail to participate in inquiry activities, or they participate in them in a disengaged manner that does not support learning. Some students showed their frustration from the little guidance offered to them. This result is corroborated in literature by Apedoe, Walker, and Reeves (2006) who state that "…these students experienced some frustration at the beginning of the course while engaged in inquiry, which they attributed to the lack of guidance they were receiving".

Students responded positively about LOs that have been used in this study. These findings are also consistent with previous research suggesting that learning objects are easy to use. Students even those who have limited computer-based skills, do not need to devote considerable blocks of time toward understanding how to use these straightforward tools (Kay & Knaack, 2007). Results were also similar to previous research as the team argued that learning objects, if carefully selected, have a considerable potential to aid student learning (Christiansen & Anderson, 2004; Reimer & Moyer, 2005; Akpinar & Bal, 2006; Nurmi & Jaakkola, 2006;). It is hypothesized

that effective learning objects (a) require students to construct and manipulate information (Akpinar & Bal, 2006; Nurmi & Jaakkola, 2006), (b) provide rich feedback and interactive illustrations (Akpinar & Bal, 2006), and (c) help students understand abstract ideas with concrete representations (Akpinar & Bal, 2006; Reimer & Moyer, 2005). In addition, it is emphasized that instructional strategies supporting the use of learning objects are critical for success, regardless of the quality of the learning object selected (Akpinar & Bal, 2006; Clarke & Bowe, 2006; Nurmi & Jaakkola, 2006; Reimer & Moyer, 2005).

Nevertheless, we believe that the implementation of this model we have proposed was relatively successful and adequate to the learning setting: tasks proposed were sufficiently stimulating to the majority of the class. This model of learning helped most students to manage the tools and techniques used during the course; freedom on the construction of presentations allowed students to explore creatively the subject domain; independent learning together with presentations contributed to preserve the uniqueness and value each student production. Finally, the open educational resources used as support were of fundamental importance.

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APPENDIXES

Appendix A: Rubric to evaluate LOs

Item	Strongly Disagree %	Disagree %	Neutral %	Agree %	Strongly Agree %
1. The Learning objects loaded quickly					
2. The learning objects were professional looking					
3. The learning objects were easy to use					
4. There was NOT too much reading required					
5. Graphics/animations assisted learning					
6. The learning objects had good interactivity					
7. Feedback from interactions were clear and helpful					

Appendix B: Interviews 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

Appendix C: Rubric to Evaluate Power Point Presentations

Category	7 pts	5 pts	3 pts	1 pt
Buttons - navigation	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
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	Some graphics are from sources that clearly state that noncommercial use is allowed without written permission	Some graphics are borrowed from sites that do not have copyright statements or do not state that non-commercial use is allowed.
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 content	Font formats have been carefully planned to enhance readability and content	Font formatting has been carefully planned to complement readability and content. It may be a little hard to read	Font formatting makes it very difficult to read the material
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