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PUBLISHER'S DECLARATION

Research and innovation in teaching and learning are prime topics for the *Journal of Instructional Technology and Distance Learning* (ISSN 1550-6908). The Journal was initiated in January 2004 to facilitate communication and collaboration among researchers, innovators, practitioners, and administrators of education and training involving innovative technologies and/or distance learning.

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IJITDL is committed to publish significant writings of high academic stature for worldwide distribution to stakeholders in distance learning and technology.

In 3 years the Journal has over 1.5 million page views and 330,000 downloads of monthly journals and eBooks.

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Editorial

Violation?

Donald G. Perrin

My email server records 2,738 emails this past 7 days of which 2,465 were discarded as spam. This is a violation of the web. Ninety percent of my mail was junk mail. I assume this means that the speed and capacity of the web is greatly diminished by spammers. I also assume that much of the power of my server and computers is similarly diminished.

My email showed further violations. *Workforce Management* presented an attractive invitation to download, free of charge, a Wainhouse Research Report entitled *Web Conferencing's Expanding Role in Training.* This report would enable me to see "how Web Conferencing is a fundamental paradigm shift in the training world." I clicked on the link and was confronted with a table that required personal information in order to receive the paper. I immediately deleted the offer and moved on. If you are volunteering personal information for somebody's mailing list, it is not free and I do not subscribe to services that use this kind of promotion.

Next, I opened an email from an IJITDL author who was surprised to find his ebook available for download and discussion from another website. I checked it out and found it was a free web-resource owned and copyrighted by an organization in Munich, Germany. You can join for free if you provide personal information. More than 400 people had already done so to access the ebook and join the discussion. I decided not to commit my personal information. However, I was troubled because normally there would have been a courtesy notification or request.

The Journal receives dozens of requests each year from universities, libraries, professional organizations, and teachers to include full text copies of articles in their information systems. The answer is always ***yes***, so long as it is not-for-profit you obtain the author(s) permission. For example, the American Society of Training Directors periodically requests permission to republish an articles from *itdl.org*.

There are many possible reasons why a courtesy request was not received. IJITDL allows free distribution of articles. Perhaps a request was made, and became one of the 2,500+ items caught in the spam filters? Perhaps the link for the download is directed to itdl.org? Or perhaps the ebook was translated into German for a primarily European audience? The facts will be researched and discussed by the Journal editors. But it raises my original contention; if you provide your personal information to get it, is it really free?

There are many reasons why websites collect personal information. One is to demonstrate value for sponsors and advertisers. A detailed list of users validates the value and the price. Non specific data is suspect. For example, in January 2007, IJITDL had over 100,000 page views, but two thirds of the requesting sites were cloaked so that their web address could not be identified. Perhaps there was a mysterious web crawler virus that pounded the site to inflate the readership? More likely, it is a reaction to misuse intended to shield the user's identity from the unscrupulous.

So, what is the bottom line? Do we add restrictions and make information less accessible? How do we encourage legitimate users and at the same time protect authors from inappropriate use of their intellectual property? Perhaps we could generate language that eliminates right to copy onto servers and information systems unless permission is obtained from the author(s) and this journal. What was once a courtesy has become a necessity!

This brings up another question. Authors are entitled to know how many people access a web article or ebook, just as an author is entitled to know how many copies of a book are sold. There is no standardized system for web use measurement. For example, IJITDL totals are reduced by publishing the entire journal as an Acrobat file - it counts as one download, but depending on how it is used, that download may represent any number of page views. Journals that provide each article as a separate Acrobat file have better tracking and more impressive numbers.

What if some GPS-like system could track institutions and bloggers and individuals who access, circulate, and discuss these articles on secondary and tertiary websites and intranets and in conferences and classrooms? This would provide real information on the diffusion of knowledge from research and theory to daily application and from entrepreneurs to organizations and end users. Would this be sufficient justification for requesting personal information in order to access information or join freely in a discussion? I don't think so. Furthermore, if you search *itdl.org* on Google, you will find over 10,700 examples of how this journal's articles are used.

By the way. The ebook problem was solved by the author requesting its removal from the secondary site.

Editor's Note: Intelligent agents can facilitate learning in a number of ways. Here it is applied in a collaborative environment to achieve a significant increase in cognitive learning. In some ways the *Système d'Apprentissage Collaboratif basé sur le modèle d'Agent* (SACA) approach reflects the concept of learning objects. This research demonstrates an approach to developing learning materials that can be used at different levels and applied to a wide range of subject matter.

Supporting Learner's Activities in a Collaborative Learning System

"Système d'Apprentissage Collaboratif basé sur le modèle d'Agent"

Yacine Lafifi, Tahar Bensebaa

Algeria

Abstract

The aim of this paper is to present the main interactions carried out between the artificial agents of a collaborative learning system called SACA in order to support the learner's activities. SACA is based on agent model in which learners collaborate to learn the concepts' knowledge of the subject to be taught and to resolve the assessment exercises. These interactions ensure the various tasks which the system provides to its learners: learning, assessment and collaboration between them. Each activity is dedicated to an artificial agent composing SACA. This paper shows results of the experiment done at Guelma University.

Keywords: intelligent agent, collaborative learning, cscl, interaction, collaboration, learning, assessment, pedagogical objective, tutor, pedagogical agent.

Introduction

Collaborative learning is a learning strategy where several learners interact with each other in order to achieve their common goals. Its impact on learner's level is ensured; it is obvious that it is necessary to be interested in learning group environments instead of individual learning environments (Okamoto, & Inaba, 1997). The systems that support such strategy are called Computer-Supported Collaborative Learning (CSCL) system. CSCL is a new emergent paradigm which spreads out classical Intelligent Tutoring System (ITS) by introducing the concept of collaboration. It is then right not to make a difference between CSCL and ITS, but rather see group learning environments as a natural extension to individual learning in ITS (Okamato, & Inaba, 1997).

Many CSCL have already seen the day (Santos, Borges, & Systems., 1999; Lonchamp, 2006). Unfortunately, most of theses systems do not take into consideration the real need of the learner such as his preferences and mainly his level of knowledge during the collaboration. We suggest then, while collaborating, to take into consideration the aptitudes and the needs of the learner in order to offer him the possibilities of an effective collaboration, i.e. a collaboration which aims to improve the learner's level and his capacities. Our work has achieved an implementation of a system called SACA (French acronym of "*Système d'Apprentissage Collaboratif basé sur le modèle d'Agent*"). The latter is an agent-based collaborative learning system that facilitates the learning process and the collaboration between different learners. Besides, it enjoys all the opportunities of intelligent tutoring systems. Artificial agents in SACA interact between them in order to ensure the following activities: learning, assessment and collaboration between learners.

The field of intelligent agents has been rapid growth over the last decade and such agents now constitute powerful tools that are utilized in most applications (Kim, Kim, & Rim, 2003). The main features of agents (as well as the modularity, the adaptivity and the autonomy) can make them good tools for designing collaborative learning systems.

Architecture of SACA

Structure of the subject to be taught in SACA

The subject to be taught is made up of a set of concepts regrouped into Pedagogical Objectives (PO). These correspond to a mental structure, an abstraction and are sometimes represented by conceptual networks. The teacher (instructor) can create pedagogical objectives, assign them a difficulty level and establish "prerequisite" relations between them (Lafifi, 2000). Each PO (X) can have a set of prerequisite pedagogical objectives that must be acquired by learner in order to learn the concepts of X (Bensebaa, & Lafifi, 2000).

In SACA, pedagogical objectives are represented by artificial agents called Domain Agents. These agents hold a set of information such as the knowledge represented by the pedagogical objective and the domain agents associated to their prerequisite pedagogical objectives.

Agent model in SACA

An agent is a computational entity that (i) executes in behalf of other entities (users, programs, etc.) in an autonomous way; (ii) makes actions in a pro-active and/or a reactive way; and (iii) presents some capabilities to learn, cooperate and move (Olguin, Delgado, & Ricarte, 2000).

Recently, various CSCL systems based on agent model have been developed. In these systems, “agents” with their own goals and functions are embedded, and perform their own tasks through communication and collaboration among them to achieve a goal as the system requires (Okamoto, & Inaba, 1997). We distinguish different kinds of projects working in multi-agent based learning environments. Some of them work on generic platform of agents but usually the focus is given to a specific agent type. Interesting results have been achieved by pedagogical agents regarding student motivation and companion agents acting sometimes as mediator of the learning process. Finally, tutor agents are usually related to student modeling and didactic decision taking (Webber, Bergia, Pesty, & Balacheff, 2001).

Among CSCL systems based on agent model, we can mention GRACILE (Ayala, & Yano, 1996), SHIECC (Labidi, Lima, & Sousa, 2000), SPLACH (George, 2000), Alice/WhiteRabbit (Blanchard, & Frasson, 2002), SIGFAD(Mbala Hikolo, 2003), I-Help(Vassileva, McCalla, & Greer, 2002.), etc.

In SACA, an agent is constituted of a set of modules and knowledge bases (see figure 1). Therefore, an agent possesses:

communication module: it allows the agent to communicate with other artificial agents in the system,

control module: based on a description of the agent‘s behaviours toward the messages that can be received from the other agents. It manages a knowledge base called *behaviours knowledge base,*

reasoning module: it uses the agent’s knowledge and a set of reasoning rules allowing it to accomplish its role in the system. It manages a knowledge base called *reasoning knowledge base,*

an optional module called *interpretation module:* associated to agents having an interaction with human actors (learner, teacher and tutor) because its main function is the interpretation of the human agents’ actions.

Multi-agents architecture:

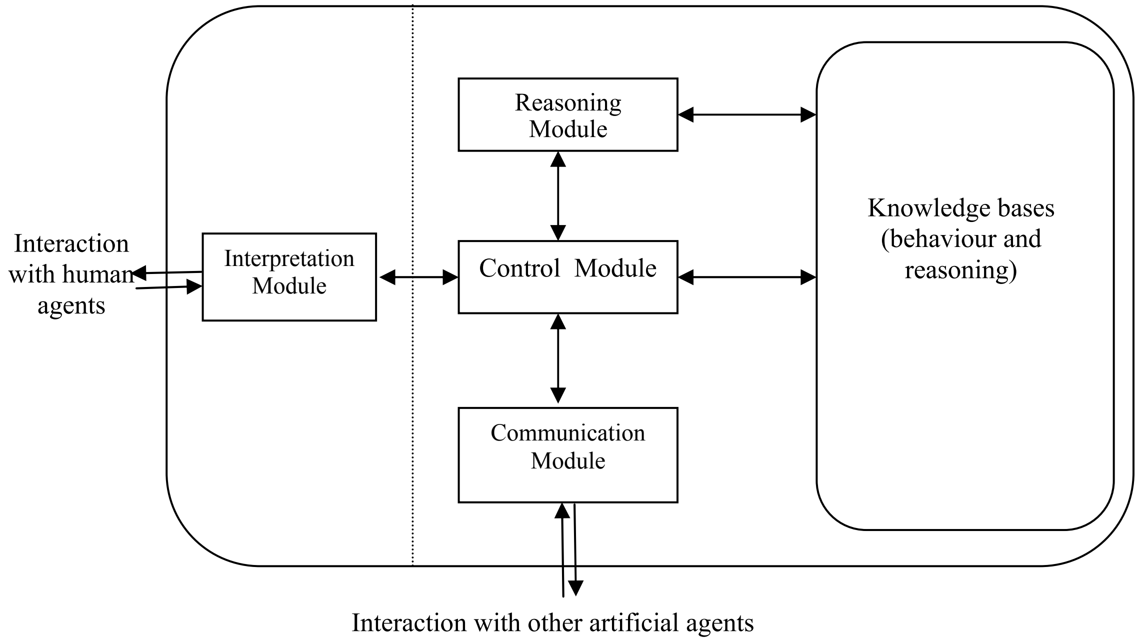

Figure 1. Architecture of an artificial agent.

SACA is constituted of a set of artificial agents. Some of them are associated with system's human actors. Each learner has the following agents:

- **An Assistant agent of Learner** (AL): It proposes to the learner an interface which makes the learning task easier for him/her. It contains a learner's student-model, his/her learning history and other information in its reasoning knowledge base.
- **Pedagogical Agent** (PA): Its role is to present the pedagogical objectives to the learner according to his/her final profile and his/her current knowledge state. They are expressed by pedagogical objectives.
- **Collaboration Agent** (CA): This agent takes into account the collaboration process between learners as well as the associated problems (interrupted collaboration, double collaboration, etc.). (Lafifi, & Bensebaa., 2006b).
- **Assessment Agent** (AA): Its role is to measure the learner's knowledge level by proposing to him/her a set of exercises from various models and difficulties.

The teacher must initialize the assessment parameters and organize the subject to be taught as well as its structure in pedagogical objectives (set of concepts). To carry out these tasks, he/she has two agents:

- **An Assistant agent of the Teacher** (AT): It proposes to the teacher an interface in order to assist him/her in the creation of the concepts and the exercises of the subject to be taught. Each type of exercises can test different kinds of knowledge. Among these kinds we can quote: «definitions», «correspondence between elements», «dependence degree», «methods and rules», etc. (Benadi, 2004).
- **A Mediator agent of the Teacher** (MT): It facilitates the communication between the teacher and the learners or between teachers themselves (Lafifi, & Bensebaa, 2004).

In SACA, learners are organized in groups where they are helped and followed-up by human tutors. Each human tutor has an artificial agent called Agent of the Tutor which assists him/her in the realization of assigned tasks: giving councils to learners and following-up their learning processes (Lafifi, & Bensebaa, 2006a).

Interactions between the different agents of SACA

Figure 2 shows the various interactions between some agents of SACA. These agents support the following activities: learning (AL), assessment (AA) and collaboration (CA).

1. Request for self assessment (concerning a PO).
2. Presentation of exercises.
3. Answers of exercises.
4. Request for the learner's assessment (concerning a PO).
5. Assessment's result of a pedagogical objective.
6. Cognitive profile of learner.
7. Result of self assessment + cognitive profile.
8. Collaboration (using the various mechanisms of collaboration).
9. Selected pedagogical objective (to learn) + request for councils.
10. Pedagogical objective to learn + councils.
11. Following-up the learners + councils.

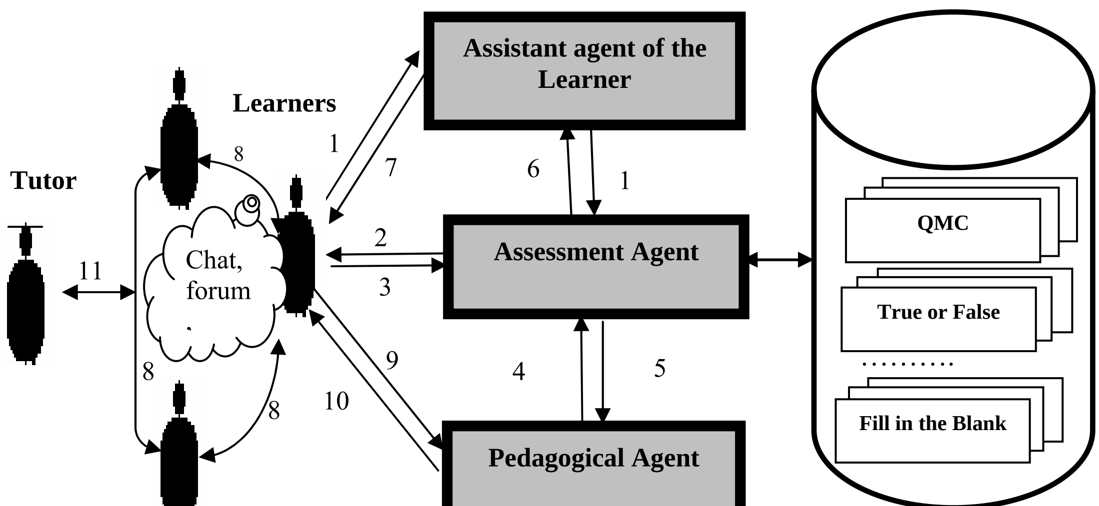

Figure2. Interactions between artificial agents in SACA.

Presentation of some interfaces

The human actors of our system are the learners, the teachers and the tutors. To each one of them is associated an interface. It is via the teacher interface that pedagogical objectives as well as assessment exercises are built. Each exercise must carefully be thought and proposed as a stage in a pedagogical progression (Govaere, 2000).

Interface of Learner

He/she can learn the concepts of the subject to be taught, self-assess or collaborate with the other learners. During his navigation, the learner moves from a concept to an other of the same agent of the domain or between the elements of knowledge of the same concept by disconnecting some links (the knowledge is presented in a form of hypermedia) (figure 3). A set of tools is offered to learners to save their states of advancing and their ways already covered.

Figure 3. Structure of the subject to be taught in SACA.

In SACA, the learners collaborate by using synchronous or asynchronous tools. These tools are:

- Forums: we have implemented three types of forums: public forum (concerned all learners), group forum (for each group), and subject forum (for each subject to be taught),
- Electronic mailing,
- Semi-structured interface and Chat (figure 4).

In each tool, the learner can save the steps of the collaboration process (list of the sent and the received messages)(Lafifi, & Bensebaa, 2006c).

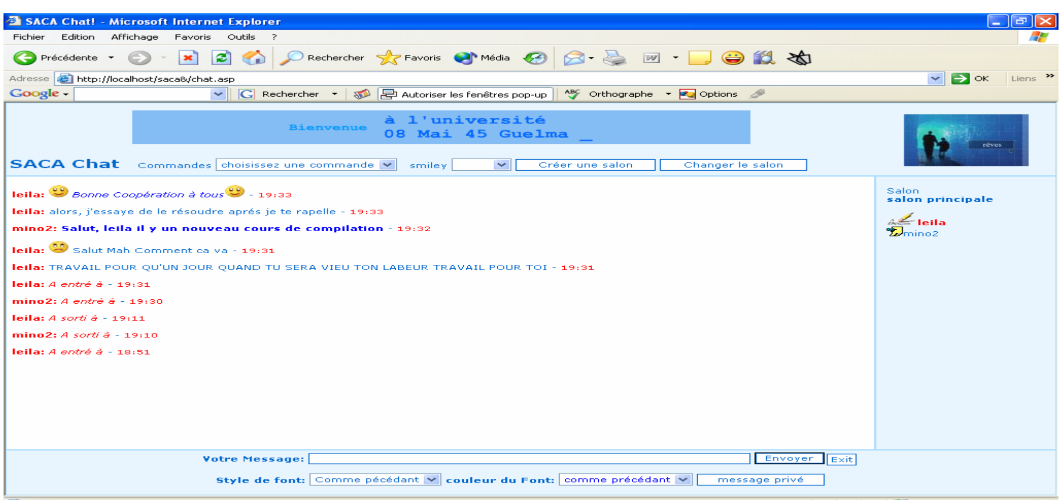

Figure 4. Collaboration tool "chat".

Teacher interface

The teacher is the first responsible on the creation of the pedagogical objectives and the exercises. For this, he/she uses some tools that make theses tasks asier for him/her (see figure 5).

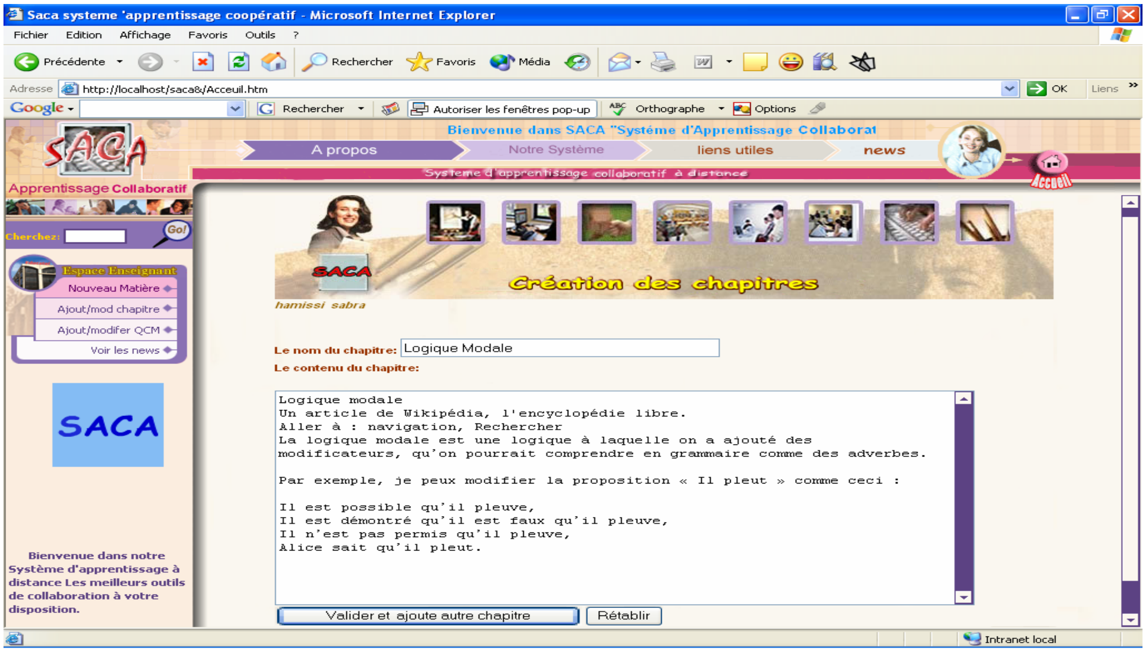

Figure 5. Creation of the concepts (of a PO) of the subject to be taught.

Tutor interface

The tutor follows-up the learners by giving to them advices and councils. He/She uses the forum by group to communicate with the learners of each group. Furthermore, he/she can see the cognitive and the social profile of each learner who belongs to his/her groups (figure 6 describes the main interface of the tutor).

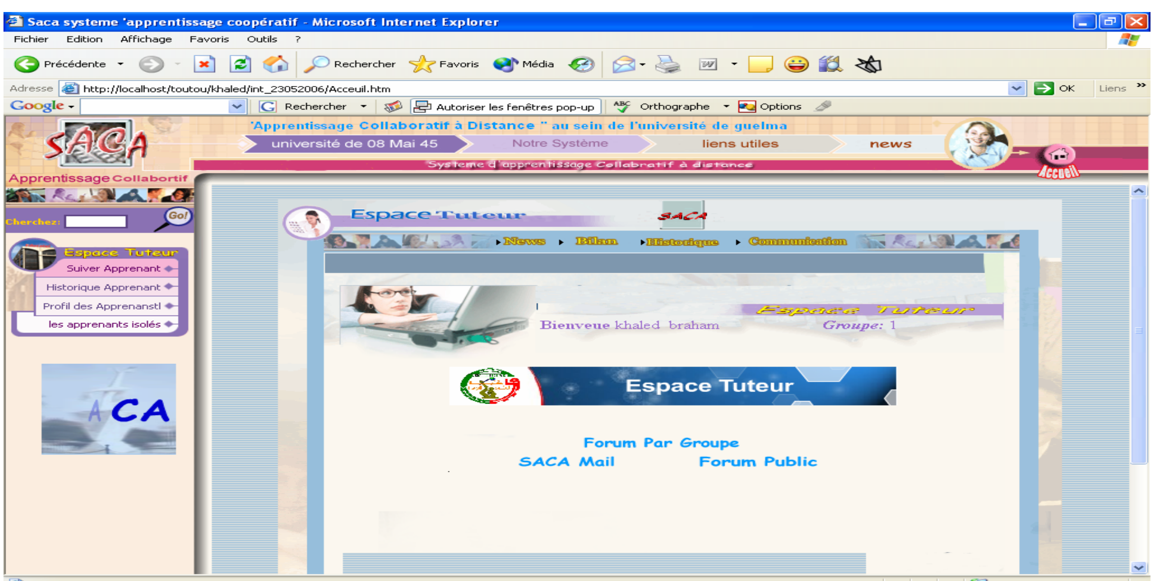

Figure 6. The tutor interface.

Experiment

Methodology

An experiment has been done at Guelma University (Algeria). The learners were from computer science department, level: 2nd year students (forty four students). These learners learned a subject called "Algorithms II" which is composed of a set of six pedagogical objectives that contain about ninety concepts. The teacher created, for each one of the concepts, a set of exercises from different types and models. These exercises belong to the following models: "Question with Multiple Choices", "True or False", "Correspondence list", "Fill in the blank", "Simulating an algorithm", "Algorithm mistakes detection", "Classification" and "Open answer with only one word".

The participants were divided into two groups (at random). The first group (control group) follows a system prototype without collaboration between learners while the second (experimental group) follows a system prototype with all the functionalities. All the learners are organized in groups followed up by six human tutors from two departments: computer science department and mathematics department. Learners access to the system using the intranet of the university (rooms of practical works at the department of computer science, internet room at the university, etc.). At the end of the experiment (after three months), a questionnaire is submitted to the learners of both groups.

Our hypothesis is that "collaboration increases the cognitive level of learners". In other words, the collaboration between learners, for resolving exercises or learning the subject's concepts, increases their cognitive levels.

Results and discussion

To verify our hypothesis, we have compared the means of control group and experimental group. To know if the difference is significant between the two means we have used paired samples t-test (student t-test) (because the size of the sample is less than 30). After using R software (http://www.r-project.org/) which is a free software environment for statistical computing and graphics, we have obtained the following results with 95% as significant level (α=0.05):

Table 1

t-test statistics

N	Mean of control group	Mean of experimental group	t_{score}	Degree of freedom	P-value
22	8.773	10.32	-2,9897	21	0.006985

From the table of t-test, $t_{0.975}=\pm$ 2.04, so $\mathbf{t_{score}<t_{0.975}}$ (-2.98 <-2.04) the difference was very significant, so the hypothesis is proved and we can affirm that "collaboration" can increase the cognitive level of learners in collaborative learning system.

As a general observation concerning the experimental group, we can say that:

- 86.36 % of learners collaborated between them.
- Through some exercises, the learners acquire new knowledge (like "simulating an algorithm" exercises).

Faced problems

According to the students, the most frequent problems they meet are:

- Some pages of the system seem to be full of information (especially those concerning collaboration). There are a lot of information on the same page (13 students agree on this problem).
- No possibility of saving parts of the subject or solutions of exercises.
- The tool help is qualified as insufficient by the majority of students.

Conclusion and Future Work

The choice of the intelligent agents for the modeling of our collaborative learning system (SACA) is promoter. The interactions carried out between artificial agents of SACA make it possible to provide an environment adaptable to the cognitive level of learners (good, weak, etc.), to ensure a fine assessment of each learner (by extracting the acquired knowledge and the not acquired knowledge) and finally to facilitate collaboration between learners (by providing some mechanisms and tools of collaboration (chat, forum…)).

The agents of SACA collaborate to support the various activities of learners:

- structuring the knowledge to be presented to the learners,
- following-up the learners,
- assessing the acquisition of the learners' knowledge,
- taking into account the collaboration between the learners,

The short period of experimentation of the system has shown the interest of the application of such strategy of collaborative learning on the cognitive and social level of learners. The final marks obtained by learners and the collaboration rate between them (86%) validate the choice of such strategy in the educational field.

A very significant results resulting from this experimentation show the effectiveness of the interventions of SACA's agents for supporting the learners' activities: collaboration agent (looking for a good collaborator), assisting Agent of learner (interventions and councils), etc. Interactions carried out between these agents increased the quality of the services provided to the learners, which make the processes of learning, assessment and collaboration more beneficial.

For future work, we plan to develop the collaborative resolution of exercises (problems) by attributing different roles to learners (moderator, supervisor, etc.) and to develop the negotiation rules used in the case of conflict between learners.

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Editor's Note: Simulation using interactive multimedia has long been recognized as a means of reducing time and cost for hands-on learning. This study shows how easy-to-use computer software can achieve these advantages, provide additional learning enhancements, and support distance learning.

Development and Evaluation of an Interactive Multimedia Simulation on Electronics Lab Activity: Wien Bridge Oscillator

Chetana H. Kamlaskar

India

Abstract

Use of interactive computer simulation to impart complex educational content enables students to experience phenomena related to abstract scientific concepts and principles. Also, it allows students to explore change in the simulated model before making changes in real world situations. The objective of this research project is to 'design and create' an interactive simulation to ensure students' preparedness to perform **basic electronics lab activities** in a real laboratory and observe circuit behavior by manipulating variables such as supply voltage, component values, etc. This computer simulation presents a step-by-step procedure of a simulated laboratory practice. Macromedia Flash MX 2004 is a tool used to build interactive simulations because it offers a high level of interactivity, cross-platform capability, multi platform delivery and scalability, ease of authoring, and superior audio capabilities.

This paper attempts to demonstrate how the interactive simulation was developed. It also presents a study that investigates the effect of using computer simulation for comprehension of a procedure and its relation to the theoretical framework. The findings from the study demonstrate that this simulation package is a useful educational tool for 'learning by doing'.

Keywords: computer assisted learning, multimedia, elearning, electronics engineering, it use, higher education, computer simulation, practical learning support, distance learning

Introduction

One hallmark of an electronics engineering technology programme is that laboratory classes accompany most lecture courses. Laboratory procedures are essential learning experiences in engineering and technology education. They enhance instruction in engineering courses and develop knowledge and skill required for practicing professionals. In traditional education, the learner has direct access to well-equipped laboratories and assistance. Distance learners go to a study centre in their region to perform lab experiments with traditional equipment, devices, methods, and techniques for measurements, data recording, and result analysis. What if the study center does not have an up-to-date laboratory infrastructure with qualified and experienced instructors? How can distance learning provide the practical skills, instructional materials, and easy access to mentors and tutors? How can they deal with non-traditional learners with learning styles that are not compatible with the opportunities available to them, or who cannot complete experiments in the limited duration of practical contact session at a regional study centre? All these factors contribute to loss of motivation, limit students' understanding of fundamental concepts and theories, and reduce learning from the hands-on experimentation.

This clearly indicates that distance learning students require 'additional innovative learning' support to enhance, enrich, or improve laboratory courses. A viable solution is interactive multimedia experimental simulation, a technology with the potential to revolutionize the way we work, learn and communicate with distance learners to meet their laboratory requirement.

Multimedia Simulation has advantages over hands-on laboratory activity. It allows students to practice more complicated and hazardous experiments, work at their own pace, obtain reproducible results more rapidly, and foster a deeper understanding of the experiments due to integration of various media. True interactivity implies that the learning process is, in some degree, modified by the actions of the learners, thus changing the roles of both the learner and the teacher. Furthermore, it helps in developing knowledge and skills required for real world activities.

To proffer all the potential advantages of interactive multimedia simulation and provide healthy laboratory learning environment, '**Wien Bridge Oscillator'** experiment from **Basic Electronics Course** were simulated using Flash MX 2004 as a prototype. This not only simulates media rich lab environment required to perform 'Wien Bridge Oscillator' but also engages the learner to,

- Perform lab activity on the computer before it was carried out in lab and real world environments;
- Practice in a low-risk environment, anytime, anywhere; without affecting real data/equipment,
- Observe the circuit behavior by manipulating variables such as supply voltage, components values, etc. and relate with theoretical concepts;
- Build self-confidence and enable learners to self-assess whether they are ready to perform lab activity effectively in real environment.

It was intended that the students use this lab simulation as part of their laboratory exercises to enhance their comprehension of lab procedure. It does not aim to replace laboratory work with simulated experiments, rather it provides students with a better idea of what to expect on entering into the laboratory. Researchers expect that this kind of pre-laboratory exposure will enable students to use valuable laboratory time efficiently and discuss the results of their work.

Research Objectives

This research project involved designing, developing and piloting interactive computer simulation. It implements instructional design principles to enhance learning via interactive multimedia in context with *Electronics Lab* activities. Hence objectives of this research are to,

1. Develop interactive simulation environment to perform Wien Bridge Oscillator experiments using state of art computer technology
2. Design instructional patterns for development of Electronics experiments using distance education pedagogy
3. Test effectiveness of simulated environment on student comprehension using randomized self test based on theory and lab knowledge with immediate feedback.
4. Evaluate the instructional pattern of simulated experiment with total quality parameter feedback sheet supplied to students and experts

Review of Related Literature

A simulation model represents a real and/or imaginary system in action. The purpose of the simulation is to enable users to explore interactions between the elements, observe system operation over the time and ask *what if* questions about the effects of changes to any of the system elements or attributes (Banks, 1998, 1999; Sauve, Renaud, & Kaufman, 2005). In learning, developing and testing theories, more emphasis is given on the interactive simulation to achieve intended and desired learning outcomes.

The behavioural theories of learning offered major advances in simulation design by modelling student learning on that of a simple organism whose behavior will be modified in accordance with externally supplied feedback. This approach implied that desired learning outcomes could be achieved through assessment of a student's entry level skills, identification of differences between entry and target skill levels, and provision of structured practice with feedback until the predefined learning outcomes were achieved (Fosnot, 1984).

Further advances in understanding instructional simulation come from cognitive theories of learning. Cognitivists argue that each student should be considered as possessing unique ways of processing information from the environment and subsequently modifying their behavior. This approach de-emphasises the importance, and even validity, of strictly defining learning outcomes and focuses instructional design on providing an environment which supports, rather than directs, individual learning.

Simulations provide a learning environment which has the ability to ‘learn by doing’. This hands-on, experiential type of learning is one of the key features of constructivist learning theory. Constructivism is one which illustrates the concept well. "Learning is the construction of knowledge not the absorption of it ... The learner must be active and must be relating new knowledge to existing knowledge" (Burton, 1988). While being learner centred, constructivism does not imply that instructional staffs are unnecessary. Evidence that "learners benefit from guidance in their perception of the learning task" is well documented (Fleming and Levie, 1978). Indeed, without proper guidance the vagaries of an individual's perception could lead to unintended and undesired learning outcomes.

The researcher also reviewed some of these examples:. Hall (2000) studied the use of computer simulations (Electronics Workbench) to perform laboratory experiments for electronics engineering technology course and compared results with using actual components in the hands-on laboratories to perform the same experiments. The quantitative research showed no significant differences in the performance of control and experimental groups. However, he found from the recommendations garnered in qualitative research that incorporating elements of both hardware and simulation into the laboratory pedagogy should help improve students’ experience regardless of the environment in which the laboratory is conducted. Campbell, Bourne, Mosterman, & Brodersen (2002) conducted an experimental study as part of an on-campus beginning circuit’s course. The results indicated that student performance was equivalent to or better than the performance of students using traditional physical labs.

Like Hall and Campbell, this researcher is not directly comparing real laboratory work with simulations alone, or with simulations that are readymade and commercially available. This researcher will test the effectiveness of self developed interactive simulations based on instructional pedagogy which suits the targeted learning goals.

Methodology

Faculty and students of the aforesaid programme were asked to participate in the evaluation of the developed simulation lab activity using a rating instrument and interviews. The research described in this paper comprises a quasi-experimental research methodology. Quasi-experimental is particularly suited to situations where it is impossible to have a control over subject characteristics like the level of knowledge, grasping capacity, background etc. and where it is necessary to select subjects for the different conditions from previously existing groups. According to Wiersma William (1991), ‘Quasi experiment research involves the use of intact groups of subjects in an experiment, rather than assigning subjects at random to experiment’. In this research, the intact group is fourth semester students (learners) of the B.Tech Electronics programme of YCMOU. Here, independent variable is product ‘practical simulation on wien bridge oscillator' and performance level of learner is the dependent variable. Researcher had taken a sample of learners and measured their performance level by administering a randomized pretest, referred as pre-experimental evaluation. Then a group of individuals was exposed to a product (media stimulus) for a period of time i.e. the influence of independent variable and finally randomized posttest was conducted to again measure the performance level to see whether there has been any change in the score.

Further, faculty and students were asked to evaluate the quality of the developed simulation using an established rating instrument and provide feedback for improvement and effective dissemination of lab experience.

Design and Development of Prototype

Steps involved in development of Prototype

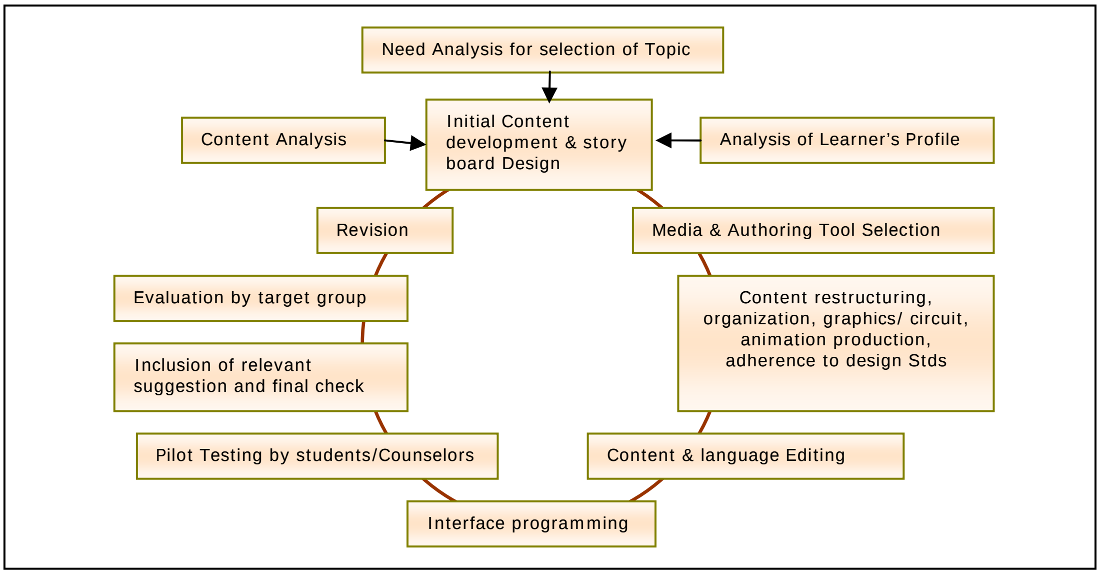


Figure 1: Design Process of Electronics practical Lab Simulation

After performing the need analysis for selection of topic, the learners' profile was analysed to match the content illustrations and activities involved in the lab simulation to the target age group, interests, culture, background, environment of ESEP students.

Learners need to become involved and motivated by the materials and to take ownership of the skills and knowledge that they acquire (Derek Rowntree, 1993); for that, presentation of content of Wien bridge oscillator was based on distance education pedagogy (through Self Instructional Material). The organization of content is shown in the following figure 2.

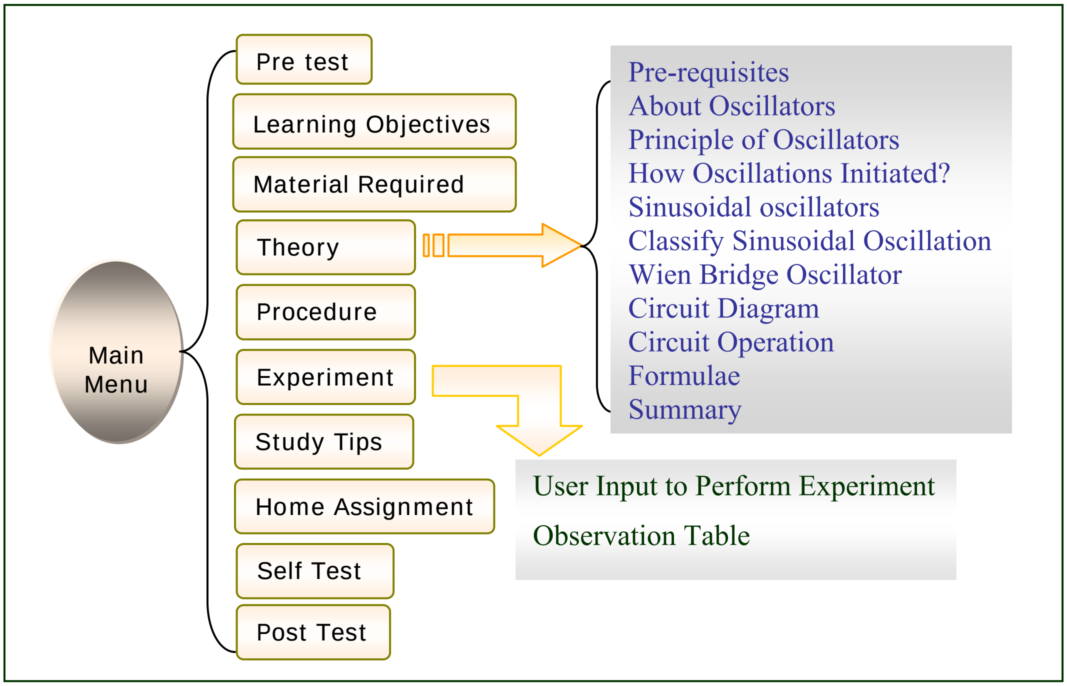


Fig 2: Content Organization

Course Description

The content contained within the simulation was intended to provide students with a theoretical knowledge base which would enhance their ability to apply concepts in a variety of situations. First outline like the course title, sequence of content, prerequisites and relation to the rest of the course content, access flexibility etc. incorporated; since the learner may access the course content in non linear fashion.

Content Outline

Content outline showed a list of specific main topics and sub-topics, presented under the module headings. For instance, in main topic theory, several small topics were made and in each sub topic minimum content was placed which made the learners learning more effective. In theory topics, prerequisites are clearly mentioned. For enhancing comprehension of major concepts only static diagram with plain text explanation is not sufficient, researcher had given focus on animated diagram/graphics with explanation. At the end of this topic, summary is given to review main points covered to reinforce the content.

The Learning Environment

The learning environment determines how learners would to learn the content. Due consideration is given to the overall approach; focus is on the learning activities or the process rather than the content. For instance, for performing the Wien bridge oscillator in simulation environment, first the learner must enter various component values, required power supply voltage within specified range of voltage. Then learners could observe response of the oscillator circuit that is output waveform on simulated Oscilloscope. Hence learner could measure the amplitude and frequency of the output waveform manually. This would provide complete hands on, how to perform the same experiment in the real environment. The user could vary the components values to vary gain and frequency along with the power supply voltages (+Vcc and -Vcc) to explore both the ideal and real characteristics of the circuit.

Incorporation of such learner/computer interaction has undoubtedly enhanced the way electronics was taught or learned. In fact, circuit simulation through state of art computer technology offers following advantages.

- Learner's role turns from passive to active, which improves learner attention.
- Learner can visualize all circuit waveforms at once and relate cause and effect, which helps in the acquisition of concepts.
- Amplitude or frequency of output waveform can be readily measured without the need for actually inserting measurement instruments
- Learner can easily change a parameter value and investigate its effect on the circuit's behavior.

Study Tips

List of reference books and web links were provided to access more information through Internet. The data sheet of IC 741 in PDF format was given to study its electrical characteristics and specification.

Home Assignment

To motivate the further reading and enhance comprehension, descriptive type of items based on the content covered were given as a home assignment.

Self Test

Self test was designed to get immediate, most realistic and effective feedback about the course content learned. The novel feature of this self test was ‘randomization’. Every time, questions were randomly pulled from large items of question bank, hence next question presented to learner was unknown to him/her. Self test consists of three types of items like ‘Multiple Choice Questions (MCQ)’, ‘fill in the blanks’ and ‘true or false’. Learner gets immediate feedback on his or her performance after giving. At the end of self test, learner’s performance is reported in the form of total correct answers, total wrong answers and total percentage.

At the conclusion of the activity, the learner is presented with a unique summary of what should have been learnt in the activity.

Media Selection

A good teacher seeks as many ways as possible to present information and ideas to learners and to stimulate their thinking for enhancing their learning process. The most common buzzword used in education is Multimedia, which is the integration of text, audio, video, graphics and animation into a single medium. Integration of different media multiplies the impact of a message. According to the research reports by Mayer and McCarthy (1995) and Walton (1993) 'multimedia has gained acceptance with many benefits derived from its use. Learning gains are 56% greater, consistency of learning is 50-60% better and content retention is 25-50% higher'. Instructional multimedia focuses on what the learner is expected to do upon complexion of the instruction.

Appropriate media selection is important to match the learning objectives and to synchronize the design and learning from it.

For example, Wien bridge oscillator circuit behavior for various components values could be shown through animation and also through a video programme. However, here multimedia is used as it offers interactivity. Learners could actually observe and feel sustain or overdamped or underdamped oscillations which were generated as per the component values provided by them; like an actual experiment. Similarly, to ‘Built oscillator circuit on breadboard’, a step by step activity is animated using different media text/photographs/images to make instruction effective.

Authoring Tool

Due attention is given in selecting the authoring tool on software features such as usability, animations, smoothness, integration, delivery, user friendliness, clientele and cost effectiveness. Each authoring tool has its own features, merits and limitations.

For creating animations *Macromedia Flash* is the industry standard. It is an authoring tool that allows to create anything from a simple animation to a complex interactive web application. It allows making Flash applications media rich by adding pictures/images, graphics, sound, and video. A file created in Flash is called a movie. A movie in Flash occupies very less file size, and hence is more popular for putting it on the Web. Flash MX 2004 is an excellent development environment for making interactive applications, enhancing productivity and ease-of-uses. It's possible to create graphical user interfaces for stand-alone and self learning (user friendly) product with increased interactivity by the use of ActionScript. This is a programming language build into Flash MX.

Interface Design and Layout

The next step was to decide about interface design and layout. Screen design serves as the internal cognitive structure that prepares the stage for learning, orienting the learning to the objectives and stimulating recall of previously learned information (Taylor, 1992). It plays the same role as "gaining attention" in Gagne's events of instruction model. Well designed screens should allow for maximum learning from the materials while providing the learner with appropriate control of the learning process (Mlheim & Lavix, 1992). Good screen designs are expected to fulfill a number of requirements: 1) focus learners' attention, 2) develop and maintain interest, 3) promote processing, 4) promote engagement between the learner and content, 5) help learners find and organize information, and 6) facilitate lesson navigation (Grabinger, 1993; Hafinafin & Hooper, 1989; Mukhedee & Edmonds, 1993).

A screen design template was developed after deciding the location of status and progress information, navigational buttons, content display control buttons, and illustrations. The graphic devices such as shading, lines, and boxes were used to separate one area from another.

Navigational item location was consistent throughout a program so a learner does not have to search for the buttons (Hannafin, 1984; Milheim. & Lavix, 1992). Kensworthy (1993) stated that keeping the keys in the same locations throughout a program helps to build confidence in the learner. Hence, after finalizing text font and color scheme, same screen template was used consistently.

Visual: The decision about the graphics attributes like color, texture, pattern and animation is important for the effective communication through graphic presentations and the richness of developed products. Information presented in text is often better recalled and retained when supplemented with pictures (Hooper & Hannafin, 1988).

Animation: A chief element of creating practical simulation environment of this product is animation. Animation is designed as a simulation of movement created by displaying a series of pictures or frames. It is a visual illusion. It builds dynamism, energy and motion to inanimate objects. It also adds the dimension of time to graphics. In this product, using key frames and tweening, the various circuit operation steps and their waveforms, important concepts and key points (text/ graphics) etc. of Wien bridge oscillator are animated to both for the explanation of dynamic processes and for heightening the impact of presentation.

Interactivity: It is nothing but the interplay between different elements of an environment, also referred as navigation. The navigation actually enables the learner to navigate from one screen to any other screen. Some of the important navigation buttons used: start, end, next, previous/back, Main menu, experiment, update diagram etc. In the layout, the placement of the buttons and/or hyperlinks was also specified to jump to sections of interest in the material. Laurillard (1987) suggests that learners should be given more control over the content, access to the content, and interaction with the multimedia content. One way multimedia can give control to the learner by providing the ability to navigate through programs at the learner's own pace and ability level (Sponder & Hilgenfeld, 1994).

Actual Development of Prototype

Based on screen design, lab simulation was developed using Flash MX 2004. Each element of multimedia- text, visuals, animation and navigation was carefully embedded in the screen so that the learner understands the content being presented and should able to work through it faster than expected. All learning activities were designed to boost the confidence in the learner's abilities and provide apparent feeling of performing Wien bridge oscillator experiment in reality.

Delivery Option for the developed lab simulation

Web compatible technologies and the state of art of compression techniques were used to keep small file size. It allows developed practical simulation of Wien bridge oscillator to be delivered for self learning in two different modes - World Wide Web delivery and stand-alone CD-ROM.

However, in today's setup, researcher has not recommended web-based delivery of product because of the poor bandwidth of internet.

The CD-ROM drive has become a standard component of computers these days, and therefore it is one of the best options available.

Pilot Testing

Pilot study was conducted on a team of 7 members. The team consists of 4 experts and 3 students. Among the 4 experts, there were two subject experts to examine the content validity, one education expert to examine instructional pedagogy and one technology expert to examine interactivity, user friendliness and ease of use. The comments/suggestions of four students from Diploma in Electronics Engineering who had already performed this experiment using traditional laboratory method, was helpful to test the usefulness of this developed practical simulation while performing the same experiment in the laboratory.

On reviewing the feedback of above team, the relevant suggestions were considered and necessary changes were made in the field tryout of product.

Features of the Developed multimedia Lab Simulation

- Allows learners to navigate freely through the simulated exercises and enables them to pause and play at any time.
- Provides easy and click access to input and output devices, making it efficient to run simulations and conduct "What if …" investigations.
- Easy to use lab interface modeled on common lab procedure
- Allows repeating of lab activities for 'n' number of time and enables self-learning anywhere anytime.
- Provides learner with a better idea of what to expect on entering the laboratory and thus make efficient use of valuable laboratory time.
- Can be used as supporting or supplementary learning material for hands-on experimentation in basic electronics course, for both conventional and distance education learner
- Associated with randomized self test and immediate feedback mechanism

- Reports learner performance in the form of total score, total wrong and total correct answers to encourage them for the use of the lab simulation.
- Web Compatible and reduced file size

Participants

The sample for this study included 34 students enrolled in an electronics course offered at 4th semester in B.Tech Electronics Engineering programme of YCM Open University. A course in basic electronics was a prerequisite for enrollment in this course. All over Maharashtra State, about 30 counselors offer academic support to total 300 learners enrolled at 30 different study centers. This represents 11.33% sample selection of total population of fourth semester. Following study centres were selected for evaluating the effectiveness and quality of the final product.

- Tee Tech Institute, Nashik
- Ahmed Abdula Garib Polytechnic, Mumbra
- Srujan Institute, Mumbai
- NDMVP College of Engineering, Nashik
- K K Wagh College of Engineering, Nashik

Other than students, total 15 faculty/experts/Counselors from the above study centres were selected for the investigation of the product.

Treatment

Evaluators were given a copy of developed lab simulation on CD (cross-platform for Windows operating systems) with both written and oral instructions, and an evaluation form to determine its effectiveness and impact on learning.

Instruments

Two separate questionnaires were specially designed and used by the researcher to collect faculty's and students' individual assessments of the quality of the product and its effectiveness.

Table 1

Format of Questionnaire

Type of Questions	Learner Questionnaire	Learner Questionnaire	Counselor/expert Questionnaire
General Information	-	8	-
Media Exposure and Use	-	2	-
Quality of product	-	26	14
General opinion	-	-	12
Based on Content	Pre Test =20 Post Test=20	-	-
Total		**36**	**26**

Faculty's Questionnaire:

The questionnaire for faculty/Counselor/expert consisted of total 26 questions / statements. Out of 26 items, on 14 items faculty were asked to assess quality parameters of the developed product in the following areas using a four point rating scale ranging from low to high and to provide a rationale for their score.

- Content
- Instructional Technology
- Language
- Multimedia and Technical quality

Whereas the remaining 12 items were open ended, asking general opinion about the product. These items were used to provide faculty with an opportunity to suggest modifications for improvement.

Learners' Questionnaire:

Two separate questionnaires were designed to evaluate 'Content Knowledge' and 'Total Quality' of the product. The content knowledge was evaluated using pre test and post test. Both pre test and post test were randomized in nature and consisted of total 20 items related to theory and performing lab activity. Bloom's taxonomy (1956) was used as a guide to develop a blueprint for the pre test and post test.

To evaluate the total quality of the product, questionnaire of total 36 items was used. Out of 36 items, 8 items were used to collect the data regarding general background information of learners, 2 items ensured the media exposure and its use. Whereas remaining 26 statements were used to collect the feedback about the practical simulation of Wien bridge oscillator, each of which was followed by four answer choices indicating degree or intensity. All these 26 statements were rated by learner after use of the product. To evaluate the effectiveness of product, rating scale was used so as to enable the respondents to express themselves more precisely.

Data Analysis

A. Learners' Response

Background Information: A total of 34 subjects participated in this study. Results of the questionnaire revealed that for B.Tech in Electronics Engineering Programme, 85% subjects were within a range of 15 to 25 years and maximum enrolled subjects for this programme were male (97%). The percentage of urban (52.9%) and rural (47.1%) showed nearly equal distribution of sample respondents. The questionnaire also revealed that maximum enrolled learners were SSC pass (58.8%), followed by HSC (29.4%), diploma (2.94%) and then ITI (8.82%) qualification. The maximum (71.94%) subjects were unemployed, learned this course full time or learned along with other education. Remaining was employed (17.65%) and self employed (2.94%), was doing this programme for self satisfaction or to acquire the latest knowledge.

From the questionnaire, it was further revealed that respondents had computer access at study centre (55.88%), home (20.59%), and (11.76%) at work place and /or at cyber cafe. Respondents were well acquainted with use of internet (73%) for performing various activities of home work, college and projects. 14.71% respondents were using CD ROMs for learning the subject content while 8.82% were subscriber to a various learning web sites.

Content Based Questions: The general awareness level of learners about the theory content and practical in-lab knowledge was collected through 20 pre test questions. It contained 17 multiple choice questions, 2 fill in the blank questions and one true or false type of question. Each question of pre test was given 1 mark, totaling it to 20 marks. Same pre test was administered as a posttest to test enhancement in understanding of content and performance level after exploring lab simulation. Both pre test and post test are randomized in nature and embedded in the product but for record keeping these tests were carried out in written form.

Questionwise Response of Respondents

The following figure 3 shows the number of respondents answered each question correctly out of 34 respondents.

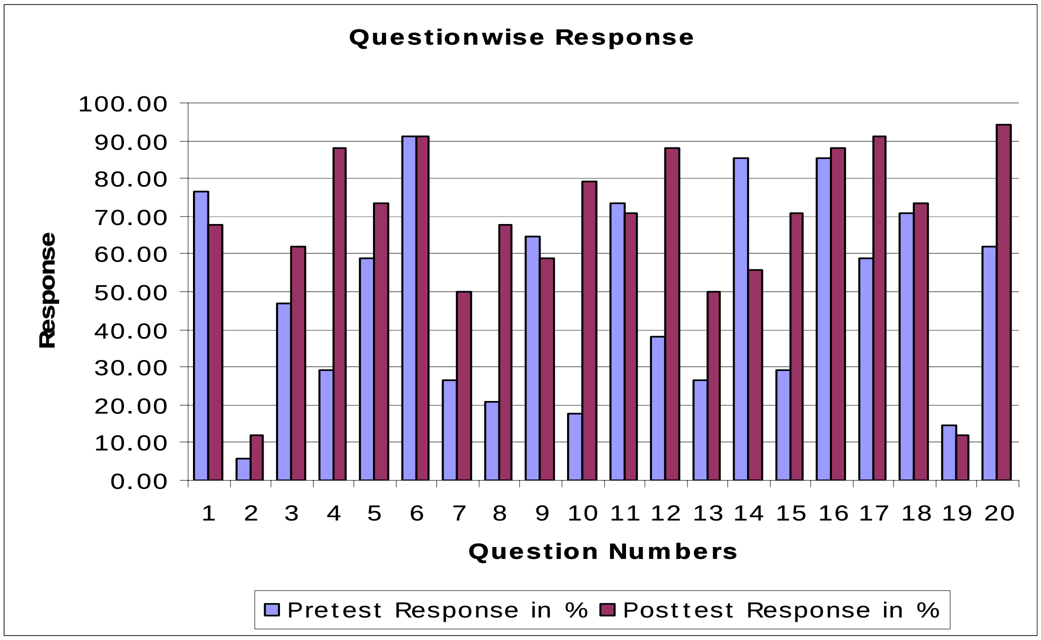


Figure 3: Questionwise Response.

For 20 content based questions, the range of correctly answered respondents varied from minimum 5.88% to the maximum 91.18% for pre test and from minimum 11.76% to the maximum 94.12% for post test. The increased height of bar indicates that the rise in knowledge level after utilization of the product.

The above analysis indicates that the use of multimedia increased the involvement of learner. A active participation of learner helps to better understand content. The most positive responses for more than 50% questions after exposure of the product itself indicated the effectiveness of the product for better understanding. However, some respondents had shown unfavorable response, due to lack of curiosity, readiness to learn through other mode, their background, learning style etc. They required more practice or efforts to achieve command over the content.

It also indicated that the respondents are more likely to use such product to enhance the end examination performance as performance score is increased in the final post test. They also felt that the information given would be useful in understanding the content of text book as all questions in pretest and post test were content based.

Statistical Analysis of Pretest and Post Test Score

Table 2 summarizes the important statistical information regarding the pretest and post test data of 34 respondents.

Table 2

Statistical Analysis of Pretest and Post Test Score

Parameters	Pretest	Post Test
No. of Respondents 'N'	34	34
Max	15	18
Min	6	5
Sum	330	458
Mean	9.7	13.47
Median	10	13
Mode	11	13
Standard Deviation 'σ'	2.3423	2.9049

The post test mean is greater than pre test mean which is an indicative of significant increase in the respondent's performance level and usefulness of product in communicating content. This indicated that the learners understood the content presented with the help of state of the art of multimedia technology, hence, product provides an enhanced or augmented learning experience at a low cost.

Table 3

Results of paired t-test

Respondents 'n'	Mean of Differences '$\overline{D}$'	Std deviation differences 'σ_{diff}'	t- value observed	Critical t-value from table for one tailed test
34	**3.7647**	**2.8290**	**7.75941**	**1.645** for 5% level of significance **1.282** for 1% level of significance

The observed value of t is 7.75941, which exceeds the critical value for rejection of 'H_o' null hypothesis (that is the mean of difference of before and after treatment is zero). Thus, we reject H_0 at 1% as well as 5% level of significance and reasonably confident to conclude that product has been effective for imparting content and learners performance is better after the use of lab simulation.

Quality Evaluation of the Developed Lab Simulation by Learners

Learners of B Tech in Electronics Engineering gave good evaluations to the simulation. They emphasized the high value that learning objectives are clear to them (90%).Only 10% did not understand learning objectives. 3% learners disagreed that the activities mentioned in this product helped them to learn with enough practice and feedback. This indicates that they require extra inputs; they may take instructor's help while performing this experiment or prefer group activity.

From the learners evaluation it was revealed that the theories, principles and procedures are explained well (87%), the content is broken down into units that are small enough to be readily learned (85%), simple language, long and complex sentences are avoided (76%).

Researcher was encouraged since learners felt that the simulation helped them to understand as how to perform experiment in the lab with better understanding (98%), build the circuit on breadboard accurately (96%), the animated oscilloscope helped to learn the effect of various component values on circuit operation (78%), the graphics animation was clear and helped to easily understand concepts (84%), simulated practical environment helped them to get overall idea and build confidence to perform experiment in lab (76%).

They felt enjoyable and exciting environment (80%) while learning through this product. The content presented in multimedia format increases the retention but 19% respondents were not sure whether they would be able to perform the experiment in lab on their own; they may require more practice or human support to guide them.

Respondents felt that the randomized self test with immediate feedback and quizzes in the product reflected the information presented in the simulations quite well (90%). From the improved mean post test score, it was found that the product strongly reinforced the theory material (82%) as well as the lab activities (86%). (60%) Respondents had assigned a slightly lower score to operate this practical simulation product without any technical knowledge. They felt that some technical knowledge is essential to access this product.

Counselor/Expert Response

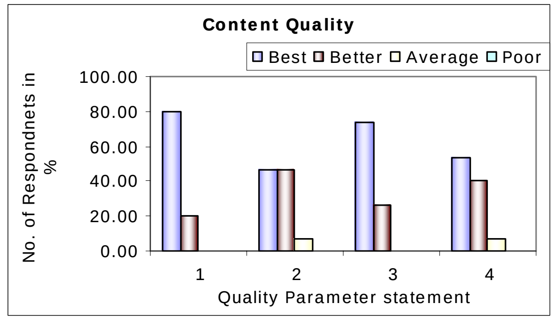
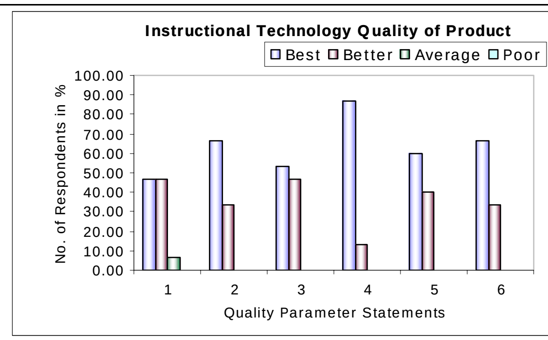
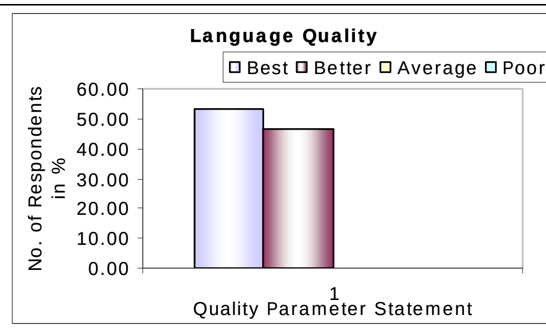
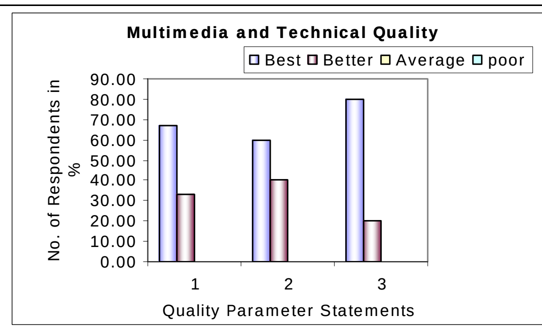
To evaluate the developed lab simulation by an individual counselors/expert, a questionnaire was specially designed and used. The analysis of the data collected from the counselors/experts is given below.

The quality of the content in the product was found best by 63.33% of the respondents, 33.33% found it better while only 3.33% found it average. The quality of instructions in the product was rated high value by 63.33% of respondents, 35.56% found it better whereas only 1.11% found it average. None of the experts rated it as poor instructional quality.

The 53.33% respondents found the quality of language in the product as best while 46.67% found it better. The multimedia and technical quality of the product was also rated as the best with 68.89%, better by 31.11% of the respondents. None of the experts rated it as average or having poor language or multimedia quality.

All counselors/experts gave positive response and overwhelmingly accepted that the content covered was related to learning objectives, effective, suitable for the target group for enhancing understanding level and presented with user friendly interface.

The following quality parameters were evaluated after exploring the simulation:

SN	Quality Parameter	Response
A	**Content**	
1	Learning objectives are correlated with content	
2	Accuracy of content	
3	Well illustrated with figures	
4	Sufficient depth and stress on each important topic	
B	**Instructional Technology**	
1	As per instructional pedagogy	
2	Use of standard symbols and abbreviation	
3	With enough number of self test questions	
4	Logical flow and continuity of presentation	
5	With proper references and study tips	
6	Use of enough number of appropriate figures along with animation	
C	**Language**	
1	Simple language appropriate for the target group	
D	**Multimedia and Technical Quality**	
1	Neat and properly drawn figures with captions	
2	Well illustrated animation	
3	User friendly interface	

General Opinion of Counselors / Experts about the Lab Simulation

An open ended questionnaire was administered gather opinions of counselors / experts about the product. Very few counselors gave any comments; some of the questions are analyzed here.

1: Does the product encourage performance-based learning?

Only 7% of the respondents gave their positive opinion with reason while 93% found that the product was useful to encourage performance based learning significantly. In their opinion, the product does not only cover practical aspect but also theory aspect with randomized pre test, randomized self test with immediate feedback and randomized post test.

2: Does the application successfully integrate technology and instruction?

All counselors/experts respondents (100%) found that the product successfully integrates instruction and technology as it incorporates various media to enhance understanding of the content and virtually gives a taste of the real world to the students.

3: Does the software increase student understanding of the topic?

From the analysis of collected data, 20% of counselors/experts gave their positive opinion with comments while 80% found that the product significantly enhances students understanding of the topic. In their opinion, lab simulation covers both theory as well as practical activities with the help of well illustrated and animated diagrams/figures/graphics. There is a logical flow and continuity in presentation of content from schematic of Wien bridge oscillator to final implementation and measurement of output of the circuit. However, some orientation is essential to students to make optimum use of such new educational products.

4: Does simulated practical environment help learner to get overall idea and build confidence to perform experiment in lab?

20% counselors/experts gave their positive opinion with comments while 80% found that the product significantly boosts students' confidence and provides overall idea about how to perform 'Wien bridge oscillator' experiment in the lab. In their opinion, product covers all practical activities for instance, how to mount circuit on the breadboard. The simulated oscilloscope provides opportunity to student to learn how to measure frequency and amplitude of the output waveform and test circuit performance for various component values.

5: Does the product provide opportunity to analyze the circuit behavior for various component values?

13% counselors/experts gave their positive opinion with comments while 87% found that the product definitely provides opportunity to analyze the circuit behavior for various component values. In their opinion, simulated lab environment offers user interface to enter/select component values for which the learners wish to find Wien bridge oscillator circuit response.

6: Does the product provide opportunity to build up confidence to mount the circuit on breadboard accurately?

From the data, it was observed that 100% respondents offered their positive opinion without any reason. In their opinion, a well illustrated and animated step by step mounting of components on the breadboard significantly helps to build up learners' confidence. Back and forth navigation feature helps to clearly understand each and every step of component mounting.

For all these questions counselors felt that the lab simulation meets all essential feature except audio. Some of them suggested, to make use of audio in streamline with graphics animation to match different learning styles and enhance further understanding of the content. Further, it offers opportunity to explore this simulated environment for even visually disable learner.

Discussion

The lab simulation was intended to give students the occasion to develop practical experience by trying lots of different conditions in rich simulations, without the fear of making a mistake. The purpose of the lab simulation was to present the materials in a format that would enhance the visualization of difficult electronics engineering concepts and process. Hence, lab simulation was developed where the user was first presented with an overview of the learning material and then given the opportunity to play in an interactive, designed space where he/she can get immediate answers to *what if* questions. Interactivity was used to further engage the learner in the learning process, which will help to develop problem solving and design skills, which are such a valuable component of an engineering education. On this background only, lab simulation was designed using instructional pedagogy and evaluated by both the users: learners and Counselors/experts. Researcher has received very positive response from them. After conducting a statistical analysis on the data collected from both the respondents, it can be concluded that effective integration of computer software into traditional laboratory activities helps students to better understand the theoretical concepts and increases comprehension by means of which enhances their performance in the lab activities.

Based on the results of this study, this lab simulation environment is not only helpful for enhancing individual or team participation performance but in a variety of ways, as:

- Introductory material enriching a Wien bridge oscillator lecture with compelling illustration/visualization as it covered essential theory with graphics/animation;
- Supplementary material in a homework assignment, presenting the material in an interactive multimedia format;
- Student centered learning

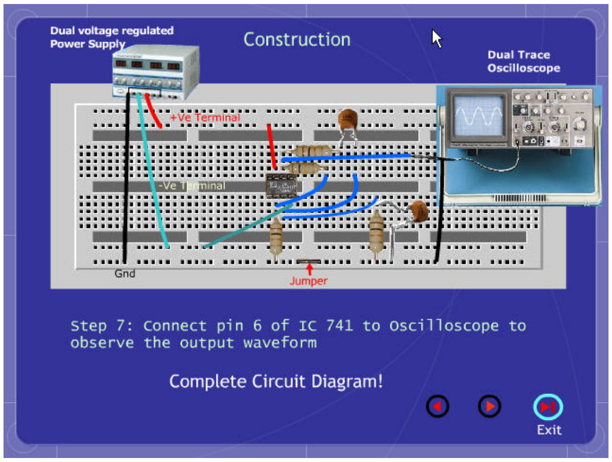
Conclusion and Recommendations

The work presented in this paper was focused on the design, development and testing effectiveness of the interactive multimedia lab simulation. The detailed analysis of the developed simulation from learners and counselor/experts was described. This simulation received very positive evaluations from both counselors and learners of Electronics Engineering.

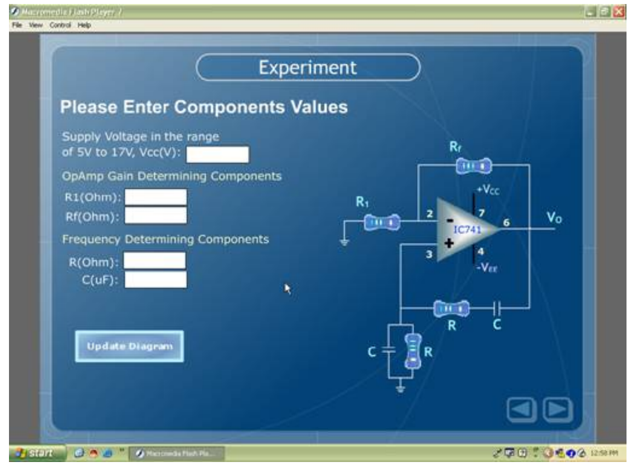
Receptivity to the CDROM was overwhelmingly positive, as counselors believed that it provided beneficial learning dimensions and addressed multiple learning styles. Questions related to the quality of CD-ROM resulted in the highest means. Learners reported that the media enhanced presentation of lab instruction was necessary for them to advance through the course. Emulating an oscilloscope to observer and measure the circuit response, and how to build circuit on breadboard were highly valued by students. The evaluation responses suggested that the students did demonstrate self-efficacy and self-reliance at the completion of the lab activity.

Both counselors and learners suggested that using both real lab and computer simulation methods to complete every laboratory exercise would contribute their learning. This conclusion has intuitive and pedagogical appeal. Repetition is often used to enhance the learning process one could speculate that it would be useful to combine the advantages of the computer simulation (ease of setup, exact measurements, reinforcement of theory) with the advantages of the hardware laboratory (hands-on experience, learning troubleshooting) to enhance the learners' overall learning experience; and appeals different learning styles. At present, however, the efficacy of developed product has been quite clearly demonstrated and surely deserves further, in depth, investigation.

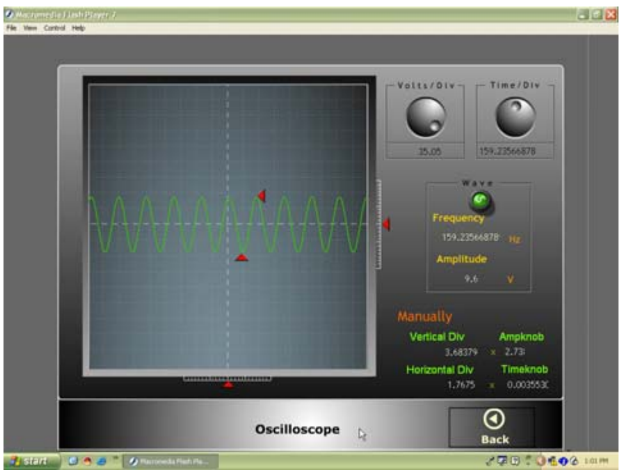
Sample screens



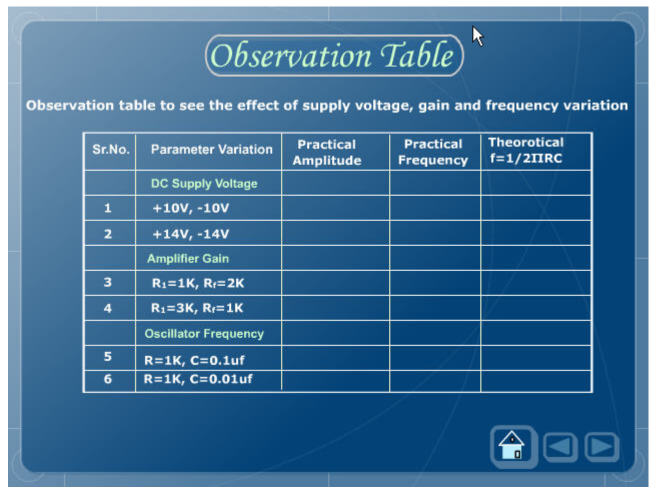
Shows Step by step procedure for how to mount components on breadboard



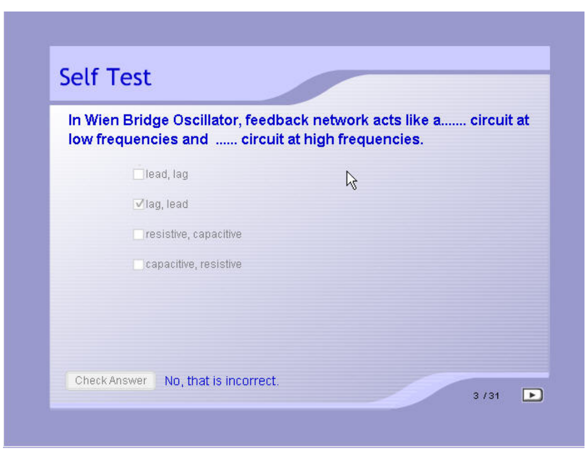
Experiment screen where learner can entered component values to observe circuit output



Animated Oscilloscope shows output waveforms for entered component values



Observation Table



Self Test screen with immediate Feedback

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Editor's Note: Multi-faceted and reuseable learning objects are moving from the laboratory into daily teaching. Earlier research shows instructional designers produce more effective learning objects. This study trains teachers to prepare learning objects and compares the product and results. Teachers produce a different kind of product with less media and more verbal explanations to achieve similar results. This researchdemonstrates a step forward and opportunities for further study.

Should K-12 Teachers Develop Learning Objects? Evidence from the Field with K-12 Students

Yavuz Akpinar, Huseyin Simsek

Turkey

Abstract

The emergence of learning objects for teachers as a focus of educational concentration is relatively new and much of the discussion has not been based on the actual development of objects, but different definitions, learning theories, properties and standards or decorative packages of learning objects (LOs). In many teacher education programs, prospective teachers take a computer literacy class separate from content methods classes and rarely engage in producing authentic teaching/learning experiences. This research addresses prospective K-12 teachers' development of learning objects. In this study, a group of prospective K-12 science teachers' learning objects were examined, evaluated and compared with LOs developed by instructional designers (IDs). A total of forty learning objects were closely investigated and effectiveness of eight of them was tried out with 180 target students in classrooms. Detailed analysis of the LOs demonstrated that while both preservice teachersrs and the IDs use similar number of instructional elements in their LOs, the IDs represent concepts and procedures with screen objects other than the text and used the text for supporting graphical objects. Both groups developed LOs similar in quality measured with the LORI 1.5. Statistical tests on data obtained from classroom usage of the LOs showed marked improvements in the students' learning.

Keywords: learning object, prospective teachers, development, evaluation.

Introduction

Teachers are responsible for tailoring instructional activities to meet curriculum standards and the unique interests and educational needs of their students. Teachers decide on "conditions, time, and strategies" of using technology in the classroom. Those decisions may include selecting learning objects that enlarge and enrich their repertoire of instructional techniques for the content to teach (Bratina, Hayes & Blumsack, 2002). E-learning systems replace the teacher as the center for learning, the teacher role shifts from lecturer to that of course developer and, once a course is in session, the learning facilitator (Cohen & Nycz, 2006). Teachers can now engage their students in computer based processes that help them build a personal knowledge base by manipulating aspects of simulated worlds, analyzing and visualizing data. Also computer based modeling tools allow students to express their theories in models that can be simulated and students will be confronted with the consequences of their ideas (Van Joolingen, Jong & Dimitrakopoulout, 2007).

To realize these potentials, the learning object (LO) development for and use in K-12 environments has become popular in related yet varied projects across the globe. In the CELEBRATE project organized by European SchoolNet (2002-2004), many such objects were made to use in classrooms. The UK government, in 2003, initiated a web portal to give teachers easy online access to a range of digital learning resources to support their teaching across the curriculum. One year later, the ARIADNE Foundation of Europe started to create tools and methodologies for producing, managing and reusing computer-based pedagogical elements and ICT supported training curricula. In the USA, Apple's Learning Exchange is one of the first repositories; the NSF funded SMETE Digital Library project was developed as a learning object repository and is used as a resource and knowledge base by both K-12 and higher education instructors (McGreal, 2004). A third project in the USA, MERLOT consortium, held a repository and uses peer-reviews of learning objects as the basis for inclusion. Australia, Canada and New Zealand have also made efforts to engage K-12 schools in design and development of initiatives (Bennetta & McGeeb, 2005).

As the use of learning objects for teaching via technology became more widespread in educational settings (Conceição & Lehman, 2003), most of the research literature on learning objects has focused on the specifications and potential designs of learning objects. Even the National Educational Technology Standards for Teachers does not require teachers to develop their technology-based learning resources, but asks to use those facilities. Interdisciplinarity in teams of LO development may be necessary for high quality as highlighted by Kay and Knaack (2005; p.231) who stated: "Developing high quality learning objects is a daunting task involving collaboration among subject specialists, programmers, multimedia designers, and evaluators".

It is often said that we don't expect teachers to write their own textbooks, so why should we expect them to design their own technology based materials? (Bratina et al., 2002). Ainsworth and Fleming (2006) reply to this question and argue that teachers do customize their textbooks to use in their classroom by suggesting an order to read chapters, explaining difficult terms, providing exercises and worksheets. They propose that much can be gained by providing teachers with simple authoring tools.

Other researchers (Bell, 1999, Boyle, 2003; Merriënboer & Martens, 2002) suggest that instructional software templates may positively affect the efficiency of the development process and compensate for the developers' lack of experience. This can be beneficial for the authoring of instructional software because more people with low instructional design and software production skills are becoming involved. Further, teacher involvement in the development of online learning resources has received attention only recently (Akpinar & Simsek, 2006; Kay & Knaack, 2005; Muirhead & Haughey, 2005; Lajoie, 2003; Oliver, Harper, Hedberg, Wills, & Agostinho, 2002; Recker et al., 2005) and researchers (Dunning et al., 2004; Jones, 2004) have suggested that with the addition of simple templates, teachers will be able to make their own objects. Haughey and Muirhead (2005) stress that it is likely that teachers will be able to develop objects requiring activities such as drag and drop, or put the items in a sequence.

In developing learning objects, different type of information might be created using traditional tools such as scanner software, spreadsheets, word processing, painting tools, HTML editors, GIFmakers, video editors/capturers and some general and specific purpose software. In LO terms, picture, animation, simulation, sound file, hyperlink, game, video, and downloadable-file are called assets. Assets can be combined to form larger files and sharable content objects (SCO). The number, quality and orientation of screen elements loaded into a lesson are an issue for development of LOs, though Learning Content Management Systems (LCMS) and authoring environments provide many facilities to create and edit screen components. The usage of those facilities should not require experience and expertise but should demand great care because research data (Hannafin & Hooper, 1989; Li, 2006; Stemler, 1997) for possible components of a computer based lesson suggest that for effective learning, screen design decisions should reflect balance among learner attributes, content factors, and processing requirements of the learning task.

Teachers with ready access to learning objects become designers who adapt and customize learning objects to fit their local needs and context (Dede, 2003; Littlejohn, 2004). In this context, learning objects become catalysts for creating locally relevant instructional solutions to support learning (Recker et al., 2005) Unfortunately most LO repositories are in English and that creates a "language divide". Teachers instructing in other languages have to do more than adaptation and customization to develop their own LOs in the light of instructional theories and available LO repositories. Perhaps LO repositories in languages other than English, especially in the developing countries, can be constructed and enriched by such efforts. Other researchers (e.g., Figg, & Burson, 1999; Oliver et al, 2002; Waddoups & Wentworth, 2002) have also pointed out the importance of including teachers in the development process. While a number of design features have been incorporated by developers of learning objects in the literature, only a few studies did a formal descriptive evaluation of the final learning object product (e.g., Cochrane, 2005; Krauss & Ally, 2005), there are not enough number of studies examining impact of learning objects developed by teachers on students' achievement .

Problems of the study

This research studied preservice science teachers' development of learning objects in an LCMS and compared those with instructional designers' LO development. The study provides a preliminary quantitative measure and evaluation of different authors' use of assets, organization of assets and instructional directions in a learning object they create. This study aimed to:

(1) compare preservice science teachers' and IDs' development of K-12 science learning objects with different (a) number of assets (picture, animation, simulation, sound file, hyperlink, game, video, downloadable-file), (b) text density on each learning objects (small amount, moderate amount and large amount of text), (c) number of instructional elements (advance organizers, questions and didactical directions), (d) number of screen orientations (templates, picture orientation, font types and font sizes, colors, main topics, sub-topics and Sharable Content Objects (SCO)) in their products, (e) the quality of LOs using the Learning Object Review Instrument (LORI, version 1.5 by Nesbitt and Li, 2004), and

(2) investigate the effect of LOs with the targeted students in real classroom environments.

Method

Subjects

To investigate preservice science teachers' development of learning objects in a LCMS, a series of studies were conducted with 40 subjects (20 preservice science teachers and 20 newly graduated instructional designers). During the study, the preservice science teachers, the *experimental* group, were studying their final year in a school of education in order to be the teachers of varying fields as Primary and Secondary School Science and Mathematics Education in 2006 spring and fall semesters. They complete their degrees in four or five years after one-year of English Language preparation. The ones who will teach in secondary schools study five years, but others study four years. Selection of the subjects was carried out on the basis of accessing them during the research activities. Before the study, they all studied at least one ICT related course, "e.g. Introduction to Computing". They were familiar with and users of information and communication technologies.

The instructional designers (IDs), the *control group*, were new graduates of the same faculty, studied in the Department of Computer Education and Educational Technology, and completed courses including instruction, learning, analyzing performance problems, and design, development, implementation and evaluation of instructional strategies and products. All participants contributed to the study on a voluntary basis.

Procedure and Materials

The materials of this study included “Instructional Materials Development course, LCMS, BU-LeCoMaS, environment, the learning objects for K-12 developed by the subjects using the BU-LeCoMaS, LO Review Instrument and achievement tests used in pre and post testing of K-12 students’ achievement. The preservice science teachers followed a thirteen week Instructional Materials Development course focusing on the development, implementation and evaluation of ICT based instructional materials. Special emphasis was given to the properties of learning objects. In this four-hour per week course (two hours theoretical and two hours practical activities), subjects were given opportunities for intensive experience in web based learning materials; some learning activities in the course were based on developing online support materials and web sites with a commercial web editor to assist K-12 students’ learn content. The course included practical sessions on how to create learning resources in MM Flash and DreamWeaver environments.

When the preservice science teachers completed their course, both the instructional designers and the preservice science teachers were provided with a username and a password to the BU-LeCoMaS server and received one-hour of training in use of the BU-LeCoMaS learning content management system. The training was carried out in two sessions. The lab was equipped with one server and 20 PCs organized in U shape in the room, all connected to the Internet. After training, participants were instructed to select a K-12 science learning task, prepare and bring their materials (assets of learning objects) to the lab in a week time to aggregate those materials and develop learning objects for K-12 science students. They were encouraged to use any sort of learning materials and assets from text to animations, and from static graphics to video segments. They were allowed to re-use graphics borrowed from Internet; they were free to use anything they found that was appropriate for their instruction.

In the following week, subjects were asked to use the system facilities and to develop a set of web based materials as learning objects for a part of their chosen K-12 science learning unit. They required enough materials to create one lesson hour of study. During their usage of the system, one of the researchers was present in the lab to resolve technical problems but did not intervene in the participants’ work. Each participant developed one learning object, a total of forty, in K-12 science.

The BU-LeCoMaS, learning content development and management system (see Figure 1), is an easy-to-use LCMS, requiring content authors with little or no technology expertise to develop learning objects. It helps online material developers, with time, place and platform independent content authoring. The architecture of BU-LeCoMaS can handle and execute any content input. It facilitates integration of textual content, sound, movie and animations into software packages and enables multimedia platform creation. It has lesson templates, layout templates and information creation and editing tools. Multiple users can easily and collaboratively construct, share and re-use content within the LCMS as well as re-use after development. Further, it supports SCORM standards, allowing developed content to be used in different learning management systems based on the idea of reusable learning content as sharable content object.

To create a small set of learning content, an authorized author can use BU-LeCoMaS to sequence and group learning materials to constitute a learning unit, the size of which varies and depends on its author. A list of available learning units and learning topics is displayed in the root window of the system. A learning topic is a subset of a learning unit. BU-LeCoMaS supports both constructing a learning unit and constructing an asset, a granular learning content. The author specifies the title and description of the material he or she is creating, selects a template, object type, tree-view type, background and foreground colors, and style sheet. The author determines “create as template” or share it as a“public template”, and decides whether ore not to include it in the subject index of the BU-LeCoMaS.

The subject index is used to search the object repository of the BU-LeCoMaS and it is used by authors to manage associations of their materials for learning units. Once the author enters relevant information and selects, for example, *LO Template Tutorial-1*, the learning unit frame is provided. The author receives a screen where the name of his or her materials appears with four sub-sections: Objectives, Introduction, Read & Study, and Images. The author can select any sections and designs. Finally, the author publishes his or her projects and set viewer permissions. Viewing options include user-only, the author's students, or anyone browsing the BULeCoMaS. The project can be downloaded as a SCORM-compliant zip archive for use outside BULeCoMaS.

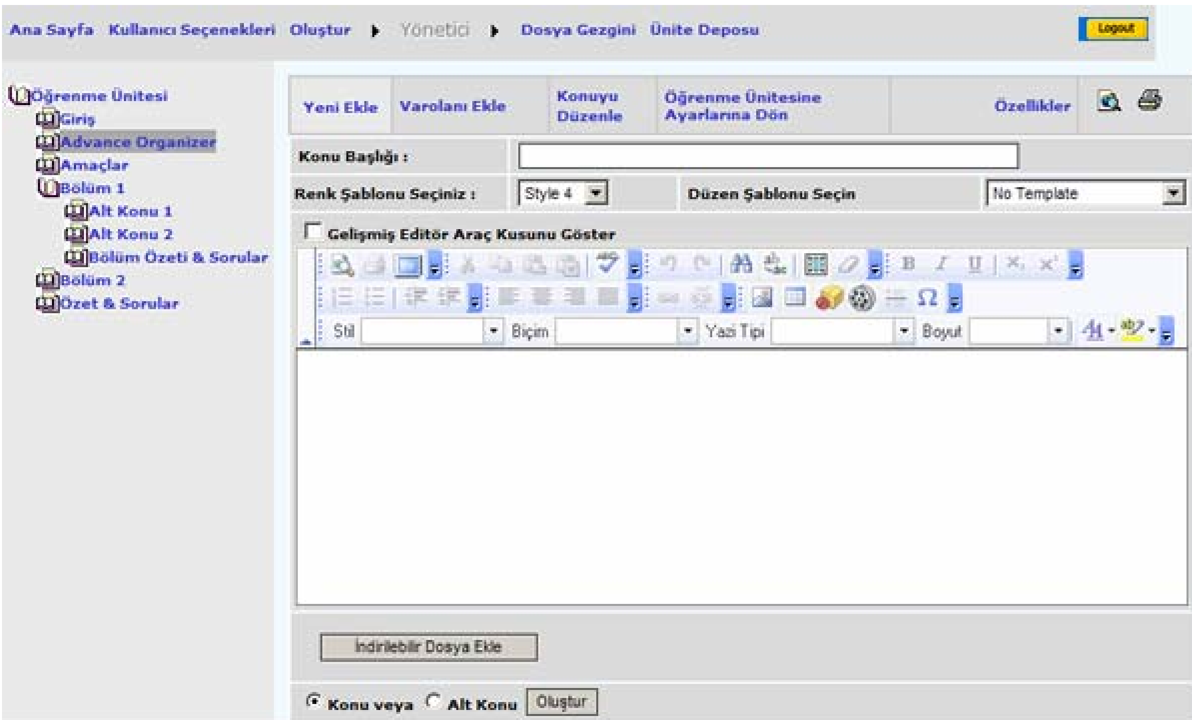

Figure 1. BU-LeCoMaS learning object development platform.

Following two consecutive days when participants develop learning objects for K-12 with the BU-LeCoMaS, one for preservicers and one for IDs, they are given a usability questionnaire with 44 five-point Likert type items and two essay items to measure the usability of the content development system, BU-LeCoMaS (five additional questions collect personal information). The scale was previously developed and used elsewhere (Akpinar & Simsek, 2006) and for testing usability of a similar tool. Cronbach's alpha reliability coefficient of the questionnaire was estimated in this study as 0.91. Each participant's total usability score was estimated. The mean of those scores was 165.25 of a possible score of 220.00.

Review of the Learning Objects and Data

The forty learning objects were analyzed by the two researchers. They studied the LOs to identify patterns and counted elements including (1) number of assets (picture, animation, simulation, sound file, hyperlink, game, video, downloadable-file), (2) text density (small amount, moderate amount and large amount of text) on each learning object, (3) number of instructional elements (advance organizers, questions and didactical directions) and (4) number of screen orientations, sub-topics –Sharable Content Object (SCO)s, templates, picture orientation, font types, font sizes, colors, and main topics in each LO.

Table 1

Data on the two groups' LOs

LORI items	Group	Mean	Std.Dev.	Rank
1. Content Quality: Veracity, accuracy, balanced presentation of ideas, and appropriate level of detail	P. Teacher	3.00	.95	19.73
	I. Designer	3.30	.43	21.28
2. Learning Goal Alignment: Alignment among learning goals, activities, assessments, and learner characteristics	P. Teacher	2.67	.92	20.70
	I. Designer	2.85	.45	20.30
3. Feedback and Adaptation: Adaptive content or feedback driven by differential learner input or learner modeling	P. Teacher	2.00	.85	16.13
	I. Designer	2.47	.53	24.88
4. Motivation: Ability to motivate and interest an identified population of learners	P. Teacher	2.75	.89	20.30
	I. Designer	2.65	.54	20.70
5. Presentation Design: Design of visual and auditory information for enhanced learning and efficient mental processing	P. Teacher	2.87	1.08	17.23
	I. Designer	3.16	.48	23.78
6. Interaction Usability: Ease of navigation, predictability of the user interface, and quality of the interface help features	P. Teacher	3.22	.83	23.73
	I. Designer	2.90	.44	17.28
7. Accessibility: Design of controls and presentation formats to accommodate disabled and mobile learners	P. Teacher	2.97	.63	22.93
	I. Designer	2.74	.34	18.08
8. Reusability: Ability to use in varying learning contexts and with learners from differing backgrounds	P. Teacher	3.00	.76	23.03
	I. Designer	2.82	.36	17.98
9. Standards Compliance: Adherence to international standards and specifications	P. Teacher	5.00	.00	20.50
	I. Designer	5.00	.00	20.50
LORI Total	P. Teacher	27.50	5.37	20.20
	I. Designer	27.91	3.37	20.80
# of assets	P. Teacher	11.90	10.02	16.15
	I. Designer	18.65	11.29	24.85
Amount of text	P. Teacher	2.15	.58	25.10
	I. Designer	1.55	.51	15.90
# of instructional elements	P. Teacher	4.90	4.73	21.18
	I. Designer	4.05	4.03	19.83
# of screen orientation	P. Teacher	3.50	1.35	13.55
	I. Designer	6.30	2.36	27.45
Usability score	P. Teacher	172.45	18.89	23.78
	I. Designer	158.05	12.14	14.75

To establish a learning object repository for various levels requires criteria to assist teachers develop, submit and assess LOs (Akpinar & Simsek, 2006). These criteria are crucial to ensure quality and accessibility of resources in the repository. For that purpose, Nesbit and Li (2004) developed a Learning Object Review Instrument (LORI 1.5). This study used it based on evidence that LORI can reliably assess some aspects of LOs. LORI 1.5 uses nine items with brief descriptive rubrics associated to each item and Likert-style five point response scale scored from low (1) to high (5). If an item is judged not relevant to the LO, or if the reviewer does not feel qualified to judge that criterion, the reviewer may opt out of that item by selecting “not applicable”. Items of LORI 1.5 are given in the first column of Table 1.

In order to evaluate the LOs developed by the preservice science teachers (see Figure 2 for an example), two researchers reviewed and rated the LOs individually using LORI scoring sheets. Following the reviewing and rating process of 20 LOs, the researchers combined the ratings and estimated average ratings for each of nine issues for a particular LO.

The reviewers’ overall ratings for a LO was obtained through summing up points given to each nine issue for a particular LO. Next, the LOs developed by the control group, IDs (see Figure 3 for an example), were made available in a web server to the IDs who reviewed and rated their twenty developed LOs independently using the LORI and the twenty IDs’ ratings were averaged. The two researchers who rated the preservicers’ LOs also rated the IDs’ LOs.

The correlation between the researchers rating and the IDs’ rating was high (0.96) so LO ratings of the preservice and control groups were combined. A formative reliability analysis of the LORI 1.5 data revealed that the overall internal-consistency reliability (Cronbach’s alpha) of the LORI 1.5 is 0.94.

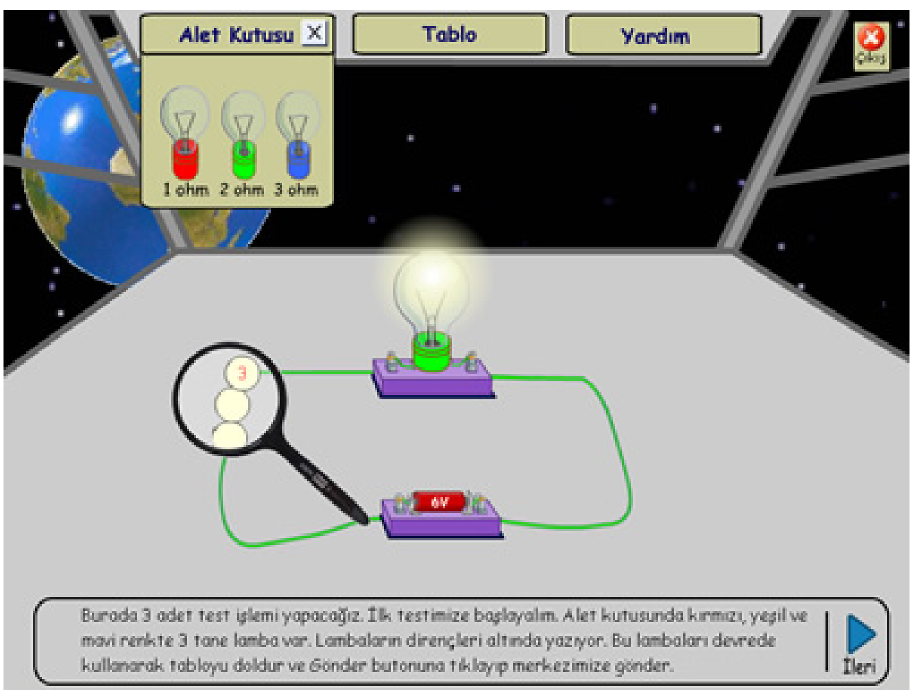

Figure 2. A learning object developed by a preservice teacher.

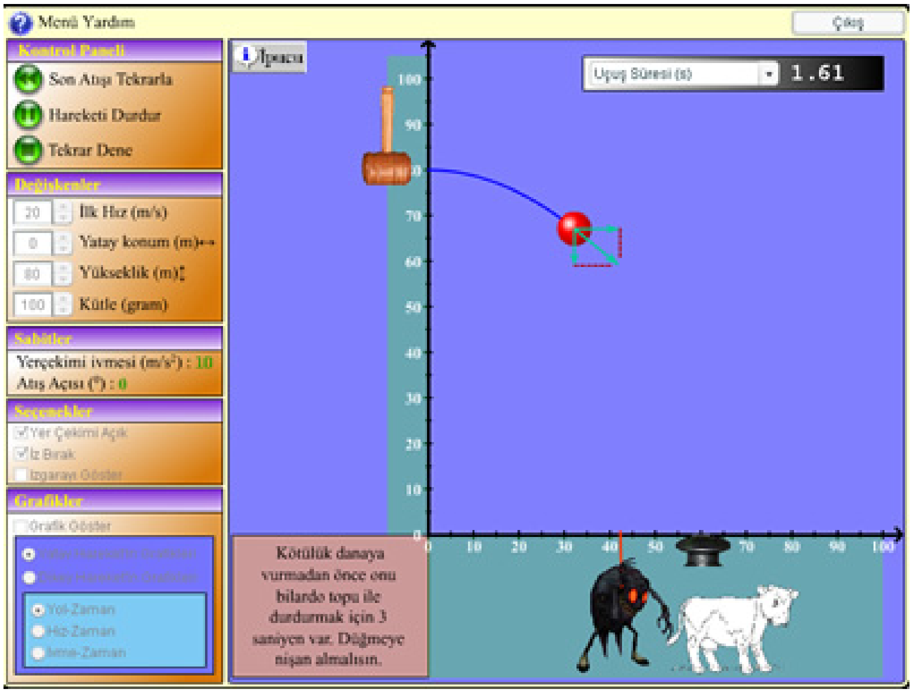

Figure 3. A learning object developed by an ID.

To test whether the preservice science teachers' and IDs' LOs are meaningfully different in terms of number of assets, amount of text, number of instructional elements, number of screen orientations and quality, (SPSS estimated Skewness and Kurtosis measures on the data sets showed that the data was not distributed normally), Mann-Whitney U tests were conducted on the groups' data (Table 1). The tests revealed that

(a) The preservice science teachers used meaningfully less number of assets in their LOs than the IDs (U=116,50; p=0,024);

(b) The preservice science teachers used meaningfully more amount of text in their LOs than the IDs (U=102,50; p=0,003);

(c) The preservice science teachers' and the IDs' use of number of instructional elements in their LOs are not meaningfully different (U=190,00; p=0,317);

(d) The preservice science teachers used meaningfully less number of screen orientations in their LOs than the IDs (U=60,00; p=0,000);

(e) The quality of LOs developed by the participants were rated by using the LORI and compared using the Mann-Whitney U test (Table 2). As the rating of LOs was carried out for the nine individual items of the LORI as well as LO overall rating, the statistical test was conducted for all of them. The preservice science teachers included meaningfully less features of Feedback and Adaptation in their LOs than the IDs (U=120,50; p=0,031). The quality of the groups' LOs did neither differ in the use of other properties nor in overall quality that LORI measures;

(f) Although the groups did not differ in most of the LORI items, whether the preservice science teachers as well as the IDs found the LO development platform usable, the usability questionnaire data was examined. The result indicates that the groups' average perception of the BU-LeCoMaS facilities was positive in general: The current state of the most facilities was confirmed. However, the preservice science teachers found the BU-LeCoMaS facilities more usable than the IDs did (U=112,50; p=0,018).

Students' Evaluation of the Developed Learning Objects

Evaluation rubrics as the LORI give a preliminary idea about instructional quality of learning objects. Studies carried out with actual users of LOs, students, may provide data about the effects of LOs on student achievement in the relevant content area. Kay and Knaack (2005) stressed that a set of pre and post-test content questions is important to assess whether any learning actually occurred. Hence, to investigate effect of the LOs in K-12 science with the targeted students in real classroom environments, all forty LOs were ordered according to their overall LORI scores and the LOs received an overall rating of 30 and over were selected: As the maximum overall rating score of LORI for a LO is 45, two-third of the top score was defined as a threshold score. There were eight LOs received an overall LORI rating between 30 and 36. The first three LOs given in Table 2 were developed by the preservice science teachers and the other five LOs were developed by the IDs. The selected LOs were then taken to classrooms where students of the target grades studied the LOs in a lesson hour.

The samples of the evaluation studies given in Table 2 were obtained from five different local schools where the preservicers do their training. Both before and after the students' work with the LOs, a pretest and post-test, containing parallel items in multiple choice formats to measure students' achievement, were administered. When the students were working with the LOs, their classroom teachers and a researcher were present, but the class teachers simply explained how students will work with the LO facilities and helped them to use the facilities. All students studied the LOs independently.

Table 2

Statistics on the students' evaluation of selected learning objects

LO Subject	Grade	Sample size	Pre-Posttest items	Pretest mean	Pretest St.Dev.	Posttest mean	Posttest St.Dev.	Paired t	df	Sig. (2 tailed)*
Mirrors	4	20	10	3.20	1.936	5.10	1.447	6.371	19	0.000
Color formation	4	20	10	2.80	0.833	4.53	1.375	4.989	19	0.000
Atoms	7	18	10	5.77	2.414	7.27	2.539	3.319	17	0.004
Motion	7	17	10	4.82	1.976	5.76	1.348	2.791	16	0.013
Electric Circuits	8	18	10	3.44	1.099	6.22	1.003	8.444	17	0.000
Solubility	9	24	10	3.00	1.685	4.67	1.351	4.097	23	0.000
H.Projectile Motion	9	47	10	3.32	1.353	2.74	1.276	2.230	46	0.031
Frictional force	9	16	10	4.00	1.549	4.88	1.996	2.573	15	0.021

*$P<0.05$;

The answers to the pre and post tests were scored and analyzed. In all eight applications, Skewness and Kurtosis measures showed that the data was normally distributed; hence, Paired-Sample t tests were conducted to compare the pre and the post test data. The analysis (Table 2) revealed that while seven of the LOs helped the sample students improve their pretest scores in the learning tasks of the LOs, only one of the LOs did not assist the students to improve their pretest scores, instead that LO about Horizontal Projectile Motion (HRM) for ninth grade lowered the students' pretest scores.

Discussions and Conclusions

In the design of K-12 science LOs, according to the data analysis,

1. the preservice science teachers embedded fewer assets (picture, animation, simulation, sound file, hyperlink, game, video, downloadable-file) and fewer screen orientations (sub-topics –Sharable Content Object (SCO)-, templates, picture orientation, font types and font sizes, colors, main topics) in their LOs than did the IDs;
2. the preservice science teachers authored more text in their LOs than the IDs;
3. the preservice science teachers developed similar number of instructional elements (advance organizers, questions and didactical directions) in their LOs as the IDs. The preservicers embedded more text and less assets and screen orientation in their Los. This may be because preservicers wanted to explain concepts and procedures directly with text and support it through other representations with screen objects.

The overall quality of LOs the groups developed was similar; the quality of the preservicers' LOs differed only in the feedback and adaptation item from the IDs' LOs. While 50% of the preservice science teachers' LOs and 20% of the instructional designers' LOs received low ratings from the reviewers in terms of adaptivity of content to learner needs that the LORI item 3 measured, 75% of the instructional designers' LOs received moderate ratings from the reviewers and 20% of the preservice science teachers' LOs received high ratings from the reviewers. Low rated LOs are unable to tailor instructional activities to the specific needs of learners: A model of the learner is not maintained in those LOs that influence effectiveness of the learning objects. The LOs mainly present content and do not use learner responses to adapt subsequent presentations and deliver rich feedback. In almost one-half of those learning objects, interactivity for navigation or selection of information is supported but the delivered feedback is poor.

The reviewers' rating of the LOs developed by the preservicers demonstrated that the preservicers are able to develop LOs in "moderate" quality. The LOs are in "tutorial" mode and most participants sequenced a few SCOs to form a LO. The contents are mostly presented in a didactic manner and student-centered activities are not common in the LOs.

Analyses of the developed LOs showed that participants prefer to use granular resources. That agrees with the findings of a study by Recker et al (2005). Participants seemed to be creating simple projects with somewhat directed activities. This may result because participants were novice developers. Comparisons of the preservicers and the instructional designers' LOs on the basis of reviewers' rating through LORI 1.5 reveal that the groups' LOs did not differ in overall ratings (except for LORI item 3, the groups did not differ at eight individual items of LORI 1.5.). The quality of the preservice science teachers' LOs are similar to the quality of the IDs' LOs.

The preservicers' design of the material type, tutorial, is somewhat different from materials the teachers developed in the study of McCormick et al (2004) where many of activities were designed to reinforce information. Recker and her colleagues stated that teachers with little teaching experience are less likely to adapt resources and more likely to use them unchanged. This study had a different outcome because formative evaluation showed a need for preservicers to receive training in development of learning materials.

The current study did not investigate whether students developed any misconceptions due to the LO, different learning/teaching strategies should be further studied. The effect of the HRM LO may demonstrate that evaluation rubrics as the LORI do not always provide enough information about quality of LOs and additional evaluation strategies may be needed. However, this study did validate the LORI to a certain extent.

Limitations in the design and development of these experimental studies avoid generalizing the findings to the larger preservice-teacher population. However, they do provide preliminary insights on the role of teachers as developers. The results are encouraging and show that preservice science teachers and IDs are able to design and develop LOs which helps students to learn. This finding supports the aggregation of content objects into learning objects by preservice science teachers; this should encourage LO projects to ask teachers to evaluate and use LOs and to involve science teachers in developing LO repositories. Pilot LO evaluation studies with students show that the LORI may be used to predict the quality of LOs; however this tool should be used with caution.

In order to avoid undesired effects, LO repositories should contain detailed usage information. Information patterns should include suggested sequence of activities based on past success; each activity should be linked to additional information regarding purpose of the activity, what the activity entails, and guidelines for teacher intervention including when to intervene. The authors' work on learning resource development environments focused on (1) a learners' record repository containing information about students' learning difficulties, teachers' experiences to overcome those difficulties, and information about student reactions that will help teachers, (2) a global task pool with critique and suggestions about each task or regime to enable teachers to have quality authentic tasks validated by colleagues, and (3) an experience repository with information about students' task manipulation and learning styles, actions to follow an activity, and type of additional help and intervention that may be needed.

Further work in this area should consider (1) collaborative LO design and how teachers and prospective teachers can be enabled to develop LOs that meet at least the issues that the LORI measures; (2) how teachers with LOs can play a meta-cognitive function for students by probing their knowledge and reasoning, monitoring participation and student engagement, and (3) expanding the framework for supporting students through teachers' LO authoring by considering the different backgrounds of students and preferred teaching/learning style of teachers/students, and (4) robust methods for evaluating students and teachers using different task regimes.

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Editor's Note: As disciplines grow in complexity, they require organizers to facilitate access to a growing volume of tools and data. Interior design is no exception. It has drawn ideas from a number of disciplines to develop visual codes as a means of classification and a database to store information about options as they are developed.

A Computer Database of Design Methodological Tool Patterns for Interior Designers

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Abstract

The purpose of this study is to increase the interior designer's familiarity with and efficiency in using common, practical design methodological tools. Interior design methods are based on fundamental methodological principles common to all design disciplines. Additionally, as interior designers encounter new and more specialized problems, they sometimes find it necessary to develop new tools of their own. Interior designers must be able to recognize the strengths and limitations of the methods available and adapt the methods to the unique design problems they encounter. Breaking down existing design methods into the collection of individual design methodological "tools" initiates systematic approaches for diverse design problems. Various combinations of tools can be applied to simple and complex design projects. To promote the interior design student's and practitioner's understanding of design methodological tools, information about 20 selected tools was organized into tool patterns. Data about each tool were recorded as data units in a database, which summarizes the information in an easily understandable and quickly retrievable form. If designers have access to various tools presented in a common language, they will generate more diverse solutions.

Keywords: design methods, design process, database, interior design, pattern

Introduction

Although systematic methods are already in use, the practice of design as a formal process can be made stronger. Interior design is a process planned to yield interiors that function well and are aesthetically pleasing (Kilmer & Kilmer, 1992). The design process has been defined as a sequence of unique actions leading to the realization of some aim or intention (Koberg & Bagnall, 1991). Interior design projects involve a number of steps in a logical order (Pile, 2003).

Jones (1992) considered the most common traditional methods to be intuition, craft evolution, and design by drawing, which rely on human memory or developed form rather than on process and are not always able to deal with complex design problems that require simultaneous progress on a series of design issues. Designers need to use multiple approaches informed by knowledge at all levels. Such is the role of systematic methods. As applied to design methods, the term "systematic" implies a step-by-step approach. The design process can be viewed as a sequence of steps or stages of varying length.

Design methodological "tools" are techniques for advancing through one or more steps of the design process. They are practical ways of doing things to get from one step of the design process to another. Jones (1992) was one of the first to break down existing methods into collections of individual tools that can be configured and reconfigured for different design projects.

The tools used by interior designers generally fall into the same two categories as those used by other design disciplines based on the fundamental design methodological principle common to all design disciplines. As interior designers encounter new and more specialized problems, they find it necessary to develop tools unique to their field's highly specialized requirements. To promote interior design students' and practitioners' understanding of tools, a uniform method for utilizing the tools is needed.

The purpose of this study is to increase the interior designer's familiarity with and efficiency in using common, practical design methodological tools. Toward this end, it will make two specific contributions: provide interior design students and practitioners with tool patterns, emphasizing their application in interior design and present these tool patterns as a computerized database for the use of interior design students and practitioners. At present, formal design methods are not well utilized by interior designers. Existing design methodological tool options, in particular, need to be introduced in a more uniform method that encourages comparison and initial use.

Design Process

Jones (1992) attempted to restructure the design process on the basis of the new design methods and techniques of problem solving into three stages: analysis, synthesis, and evaluation. Jones (1992) acknowledged that the steps could be described simply as "breaking the problem into pieces," "putting the pieces together in a new way," and "testing to discover the consequences of putting the new arrangement into practice" (p.63). As the steps are cycled, each cycle is less general and more detailed than the one before it.

Cross (1986) suggested that systematic design methods allow both creative and logical thinking. Creative thinking refers to the random ideas and insights in designers' minds, while logical thinking refers to data, information, and requirements outside designers' memories. This binary way of thinking permits and encourages extensive problem exploration and analysis to identify all the factors and their relationships so that all solutions for each factor can be identified.

Based on a comparison of acceptable problem solving procedures, Koberg (1979) suggested a universal process of problem solving, noting that each procedure shows the basic components of analysis, synthesis, and definition, where definition is a bridge between analysis and synthesis. According to Koberg (1979), analysis is individualized and specific, but synthesis involves three parts: searching for ideas, making selections, and implementing selections. He then concluded with two steps that indicate self-motivation and self-improvement: acceptance at the beginning and evaluation after the steps have been completed, for a total of seven steps.

Interior designers, as in most disciplines, have developed unique characteristics for their professional role. Interior design projects are taken through the following steps: programming, conceptual design, design development, contract documents, contract administration, and evaluation. Seemingly linear, there is much reiteration and comparing of preliminary solutions to established objectives and needs.

Design Methodological "Tools"

Design Methodology

Design methodology refers to the study of the methods of designing dealing with the principles, practices, and procedures of design (The Design Methods Group, 1979). Bayazit (2004) states that the complexity of design problems after World War II brought attempts to restructure the design process on the basis of new methods and techniques because traditional methods were too simple and focused only on the design product. An understating of the nature of the rising complexity in problems facing designers brought a need to develop new methods to handle various variables in the emerging design problems (Atwood, McCain, & Williams, 2002). The design methods movement developed at subsequent conferences: Birmingham in 1965, Portsmouth in 1967, Cambridge, MA in 1969, London in 1993, New York in 1974, Berkeley, CA in 1975, Portsmouth again in 1976 and again in 1980 (Cross, 1993). The Design Methods Group (DMG) was founded in 1966 to promote education and communication in the fields of design methodology and applied design methods and in the theories of design and designing. The direction of thinking on design methods has changed dramatically through first, second, and third generations. The first generation's approach concerns the procedures of design and applicable techniques such as design strategies and systematic design techniques (Fowles, 1977). First generation designers "break the problems into parts, analyze and solve the problems of the part, and recombine the part into a synthesized solution" (Nasar, 1980 p. 90). Their terminology varies based on differences in the scale and the level of abstraction. For example, "Asimow (1962) with 'design elements,' Jones (1963) with 'factors,' Archer (1963/4) with 'sub problems,' and Alexander (1964) with 'misfit variables'" (Broadbent 1979, p. 41).

Second generation designers consider first generation methods suited for the solution of "well-constrained" problems since these methods are drawn from the systems engineering techniques of military and space missions. Second generation designers intend to extend the scope of methods to the "ill-constrained problems" of planning and design. The main characteristics were summarized by Fowles (1977), based on Rittel's description:

- Expertise does not reside solely in the professional.
- Design should be an argumentative process within a network of issues.
- Any given issue can always be viewed as a symptom of a more fundamental one.
- The 'transparence of argument' acknowledgement that the nature of new questions that arise, in the design process, are determined by the line of thinking already taken.
- The 'principle of objectification' to increase the probability of raising the right issues: to reduce the probability of forgetting something that will become important after the fact.
- Clients maintain control over delegated judgment.
- Clients participate in forming the solution thereby eliminating implementation problems. (p. 24)

Broadbent (1979) suggested a third generation of design methods, adapting Popper's "conjectures and refutations" model of scientific methods, synthesizing the better aspects of both the first and second generations, but suggested that designers seek expert design conjectures while allowing rejection by the people for whom they design. This approach promotes growth potential by giving clients the right to make decisions with the information provided by designers (Nasar, 1980). The third generation considers plurality a positive value. Dulgeroglu-Vuksel (1999), for example, insisted the major tendencies in design methodology today encourage the plurality of views, citing Kuhn's "incommensurability" theory, which claims that one situation is seen differently as the process is changed.

Tools for Interior Designers

Design methods have been difficult for novice design students to understand and apply. Jones (1992) was among the first to advocate a standardized method of introducing tools. The idea of tools popularized the systemic approach to diverse design disciplines and the application of tools to design problems. Variously combined tools are widely applicable to simple and complex design projects, and can be developed and added to address the changing needs of specific design disciplines. However, tools for use by interior designers have not been given much attention. Through a literature review of design processes and design methodological tools, this study extracts tools for use by interior design students and practitioners.

As with most other disciplines, the interior designer's understanding of tools is enhanced by a uniform system of organization. Wade's (1983) unified format maximizes the clarity of design methodological tools and the ease of use. This might serve as the foundation for a standardized format. One important refinement could be illustrations of tools to help interior design students and practitioners understand and memorize the tools. Illustrations are more quickly and directly translated to the brain than the written word and aid in learning and remembering the tools (Dreyfuss, 1984).

Identifying steps in the interior design process aids designers in choosing particularly suitable design methodological tools. Comparing inputs and outputs (Jones, 1992) simply does not show clear relationships within the design process. Jones's chart involves manipulating the inputs and outputs of the design process rather than the process itself. DMG's three design phases are based on three fundamental types of acts in designing rather than on design processes. The tools grouped under each step of the interior design process indicate when the tools prove beneficial in the interior design process. In addition, a note explaining use in interior design helps designers determine how to use tools for specific projects.

The information sources for design methods show that applications of tools to interior design processes are beyond the scope of a single review. Books about design methodology generally focus on the use of methods in architecture and industrial design.

In summary, this study proposes to develop uniform methods of introducing tools for interior design methods by employing a two-fold approach: 1) providing a fundamental methodological principle common to all design disciplines and 2) showing the special relevance of the methodology to interior design.

Method

To introduce existing design methodological tools in a more uniform method that encourages comparison and initial use, this study explored the concept of pattern, summarized as a method of maximizing the clarity, consistency, and expediency of learning to use design methodological tools. The composition of tool patterns was developed based on a critical analysis of Wade's systematic methods description format. Wade's categories of information were translated into patterns. Illustrations of patterns were added using a cohesive graphic language to enhance an understanding of each tool's attributes. For relevance to interior design, tool patterns were identified with the applicable steps of the interior design process, and notes concerning each tool's application to interior design were also included.

Information sources for selecting tools were based on references suggested by the DMG (1979, 1985) and the National Council for Interior Design Qualification (NCIDQ) (2000). Tools were selected based on their frequency of citation in the sources. Completed tool patterns were put into a computerized database; information included a name, a general description, a guideline for use, an illustration, applicable steps of the interior design process, a note for use in interior design, and documentation of all sources. To accomplish the purpose of this study, several steps were required:

1. Develop the composition for tool patterns that include a name, general description, guideline for use, illustration, applicable steps of the interior design process, a note for use in interior design, and documentation of all sources.
2. Select tools based on frequency of mention in references by DMG and NCIDQ.
3. Organize information about the selected tools into tool patterns.
4. Develop illustrations for tools.
5. Record all information in a computer database.

Pattern Development

Patterns have traditionally been used to summarize common problems of built environments and the solution concepts related to them (Alexander, Ishikawa & Silverstein, 1968; Duffy & Torrey, 1970; Alexander, 1977; Protzen, 1978; Alexander, 1979; Gullichsen & Chang, 1985; Jutla, 1993; Allen, 1992; Alexander, 2004). Christopher Alexander and his colleagues (1968) used a method they called pattern language to generate building designs. The patterns summarized, in text and graphics, common problems of built environments and related solution concepts. The patterns were intended to suggest prototypical designs of imaginary buildings with no special sites or clients and were based on increasing the understanding that “essential, generic ideas, can be applied many times over to special cases” (Alexander, Ishikawa & Silverstein, 1986, pp. 1-2). Each of Alexander’s patterns was described in a consistent format with an illustration for ease in understanding and use. Each pattern addresses one or more small problems, but the real promise and originality of the approach is that patterns can be added to one another to solve whole design problems. The analogy Alexander used draws on the idea that language collects, retrieves, and combines words to communicate, using certain rules, stating that designers are able to “create an infinite variety” of new and unique buildings with pattern language just as ordinary language gives the capability to “create an infinite variety of sentences” with words (1979, pp. 185-186). Here patterns were used to manage abstract information, specifically information on tools, emphasizing their use in interior design.

Tool Patterns

For this study, information about tools was summarized into patterns to increase student and practitioner awareness of design processes and understanding of design methodological tools. The resulting patterns portray different types of design methodological tools in a uniform method that is easily accessible. These tools can be used for any interior design problem regardless of size and scope because designers can combine appropriate patterns to solve the specific problems of their projects.

The composition of tool patterns was created by combining the concept of patterns with Wade’s design methods description format. The composition includes 1) a name, 2) a general description, 3) a guideline for use, 4) an illustration, 5) applicable steps of the interior design process, 6) a note for use in interior design, and 7) documentation of all sources.

Illustrations used a cohesive graphic language to enhance understanding of each pattern’s attributes. Applicable steps of the interior design process and a note for use in interior design were intended to strengthen the relevance to interior design application and efficiency in applying the tools. All sources were cited to encourage further study about the tools.

Illustrations of Patterns

The main advancement of this study beyond Wade’s work was the addition of illustrations, intended to express procedures to aid in learning and remembering tools. Based on reviewing previous illustrations of design processes and methods (Best, 1969; Laseau, 2000; Jones, 1992; White, 1975), a high level of abstraction was necessary for the illustrations in this study. Laseau (2000) stated that these illustrations show three basic parts: identities, relationships, and modifiers. Different shapes, such as circles, squares, triangles, and stars, show identities by means of their contrast. Lines represent relationships. Then, identities and relationships are modified by a hierarchical system. The significance of parts and the different levels of intensity in the relationship between parts are expressed by size, number of lines, line widths, relative size of dashes, and spaces in dashed lines.

Illustration components were developed to express tool attributes, which can be systematically applied to various tools by combining the elements of identities, relationships, and modifiers. The results are detailed in the Analysis of this paper.

Selection of Tools

To develop a balanced awareness of common tools shared among the various design disciplines and those used more exclusively by interior designers, tools of both types were selected for this study. First, common tools were selected from references by the DMG based on frequency in sources. Second, interior design tools a reading list about interior design published by NCIDQ (2000).

To gather the common tools, 12 sources (six proceedings of conferences, one journal, and five books) were consulted. One proceeding of a conference, The Design Activity by Maver, was excluded from among the references by DMG (1979, 1985) because it was out of print. Therefore, to begin the study, common tools were gathered from one journal, Design Methods: Theories, Research, Education and Practice by DMG, and from one book, Design Methods by Jones. In its journal, the DMG (1979) described design methodology and design methods as a series of reference sheets on topics of interest to the new student of design. The journal introduced 14 tools. In his book, Jones (1992) published a survey of 35 tools in association with the Council of Industrial Design. Each of the ten tools finally selected for this study were mentioned in more than half of the 12 sources.

To gather frequently used tools for interior design, six books from the NCIDQ reading list (2000), all about the role of the professional interior designer, were consulted. From these six books, 49 interior tools were first gathered, later, shortened to ten tools to match the number of common tools. Of the ten selected, nine were mentioned in each of the six sources. The tenth tool, post occupancy evaluation, was mentioned in five of the sources and was added in order to address each step of the design process.

Computer Application

A computer database was chosen as the method for managing information due to the ability to expand, accommodate, and manipulate many variables effectively. In using such a database, it is expected that interior designers will be better able to explore methodological tools that address their specific needs. FileMaker® Pro and Adobe® Illustrator® software were chosen for the database. FileMaker® Pro, database management software, has an outstanding reputation as a popular and powerful program for novice users. Creating a database file with FileMaker® Pro is similar to designing a data form. Text information, separated as data units, was recorded in the specific field “text” in FileMaker® Pro. Illustrations were drawn in Illustrator® and then copied to and stored in the specified field “container” in FileMaker® Pro.

Results and Discussion

Review of Tools Selected

Although this study focused on developing a methodological framework for interior design, it was intended to put forth an interdisciplinary approach rather than a narrow interpretation for an isolated field. The process of selecting tools explored both shared fundamental design methodology and specific needs of interior design. The common tools were selected based on frequency of citation from DMG (1979, 1985) sources, and the interior design tools were selected from NCIDQ (2000) sources.

This study attempted to select tools from each step of the interior design process to provide alternative techniques to advance a particular step. However, the common tools were heavily weighted toward programming (Table 1), but each with a different scope.

Table 1

Distribution of Selected Tools

Interior Design Paradigm	Common Tools	Interior Design Tools
Programming	1. Brainstorming	
		2. Budgeting
	3. Classification of Factors	
	5. Cost-benefit Analysis	
	6. Critical Path Methods	
	7. Determining Components	
		8. Diagrams and Schematics
	9. Interaction Matrix	
		10. Interview of Clients
		11. Inventory Checking
	12. Morphological Approach	
	13. Performance Specification	
	19. Systematic Search	
Schematic Design	1. Brainstorming	
		2. Budgeting
	18. Synectics	
Design Development	1. Brainstorming	
		2. Budgeting
	18. Synectics	
Contract Documents		17. Specifications
		20. Working Drawings
Contract Administration		4. Construction and Installation Monitoring
		15. Punch List
		16. Purchase Orders
Evaluation		14. Post Occupancy Evaluation (POE)

The selected tools reveal the diverse types of tools in terms of time and energy for applying them to design. For example, “determining components” requires a great deal of activity and effort to restructure the components of the design problem while “brainstorming” produces many ideas quickly, although the ideas should be further developed by classification. “Specifications” requires a great deal of time and thought to accurately identify construction materials and methods. However, “purchase orders” is a relatively easy task if all items to be purchased were thoroughly documented in specifications.

The selected interior design tools indicate consideration of the professional practice of interior design projects. Interior design tools for programming such as “interview of clients” and “inventory checking” are intended to define design problems based on clients’ present and future needs. Tools for contract documents: “specifications” and “working drawing,” and for contract administration: “construction and installation monitoring,” “purchase orders,” and “punch list,” show the consideration of practical methods to transform design ideas into the reality of interior space.

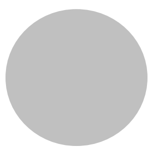
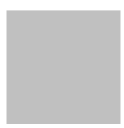
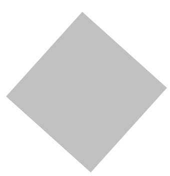
Review of Pattern Development

The new contribution of this study and the strength of the resulting tool patterns was the inclusion of illustrations for ease of understanding tools. To develop the illustrations of tool patterns, illustration components that represent the selected tools' attributes were created. Three basic parts of abstract illustration suggested by Laseau, identities, relationships, and modifiers, were applied.

Representations of design steps, activities, issues, and ideas were developed. Circles, squares, and diamonds were chosen to identify design steps (Table 2).

Table 2

List of Illustration Components: Design Steps

Graphic	Name and Meaning	Shape	Remarks
	Creation	Circle	Programming, Conceptual Design, Design Development
	Implementation	Square	Contract Documents, Contract Administration
	Evaluation	Diamond	Evaluation

Circles identified the steps in the interior design process: programming, conceptual design, and design development. Squares identified the implementation steps: contract documents or contract administration. Diamonds identified the steps of evaluation. Representations of design activities for design methodological tools were also developed (Table 3). Activities performed by young architects in the office consist of drawing, information seeking, thinking, verbal communication, and written communication (Broadbent, 1988). Illustrations for these five office activities and for site observation were developed. The illustrations of design activities were then combined with the illustrations of design steps. For example, a dashed line that identified drawings could be applied to a circle, a square, or a diamond.

Dots identified design issues within a design problem (Table 4). Although different terminologies based on differences in the scale and the level of abstraction were used; "Asimow (1962) with his 'design elements,' Jones (1963) with his 'factors,' Archer (1963/4) with his 'sub problems,' and Alexander (1964) with his 'misfit variables'" (Broadbent 1979, p. 41); they were represented by the same shape for illustrations in this study.

Stars identified design ideas to solve design problems (Table 4).

Table 3

List of Illustration Components: Design Activities

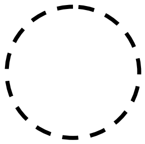
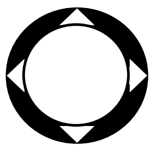
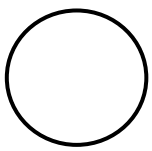
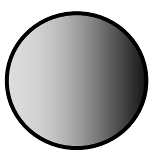
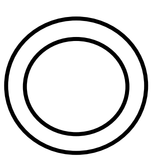
Graphic	Name and Meaning	Shape	Remarks
	Drawing	Dash line (Circle, Square, or Diamond)	
	Information Seeking	Filled Double Lines with Four Triangles (Circle, Square, or Diamond)	
	Thinking	Single Line (Circle, Square, or Diamond)	
	Site Observation	Gradation (Circle, Square, or Diamond)	
	Verbal Communication	Filled Double Lines (Circle, Square, or Diamond)	
	Verbal Communication (from Different Disciplines)	Filled Double Broken Lines (Circle, Square, or Diamond)	
	Written Communication	Double lines (Circle, Square, or Diamond)	

Table 4

List of Illustration Components: Design Issues and Design Ideas

Graphic	Name and Meaning	Shape	Remarks
●	<u>Design Issues</u>	Dots (Inside Circle, Square, or Diamond)	
✷	<u>Design Ideas</u>	Stars (Inside Circle, Square, or Diamond)	

Relationships were presented as lines and arrows combined with the illustrations of identities (Tables 5 and 6). For example, design steps were combined with arrows to clarify the order of sequences. Scattered design issues were linked if they had strong relationships. The design issues were grouped in boundaries that categorized those related.

Modifiers, such as size, line width, and relative irregularity of lines, enable designers to recognize the most important elements first (Table 7). For example, selected design issues or design ideas were slightly bigger than the original ones since a larger size and thicker line denoted a critical path. The boundaries were changed from organic to elliptical shapes as the categories of design issues were refined. The degree of irregularity showed the process. Several specialized illustrations, such as the dollar sign, plus sign, and check mark were included in illustration components (Table 8). Figure 1 shows the process of illustrating the "classification of factors" tool.

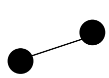
Table 5

List of Illustration Components: Relationship of Design Activities

Graphic	Name and Meaning	Shape	Remarks
⇒	<u>Sequential Flow</u>	Large Arrow Connecting Circles (Squares or Diamonds)	

Table 6

List of Illustration Components: Relationship of Design Issues (Ideas)

Graphic	Name and Meaning	Shape	Remarks
	<u>Cohesion</u>	Thin Straight Line Connecting Dots (Stars)	

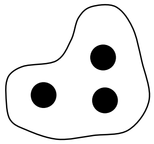
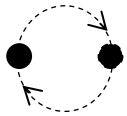
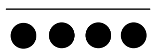
	Categorization	Organic Boundary Grouping Dots (Stars)	
	Comparison	Circular Dash Arrows Between Dots (Stars)	
	List	Single Straight Line Under the Row of Dots (Stars)	
	Organization	Double Straight Lines Connecting Row of Dots (Stars)	

Table 7

List of Illustration Components: Modifier

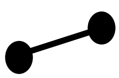
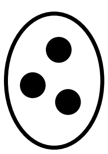
Graphic	Name and Meaning	Shape	Remarks
	Selection	Thick Straight Line Connecting Dots (Stars)	
	Refined Categorization	Circular of Elliptical Boundary Grouping Dots (Stars)	

Table 8.

List of Illustration Components: Specialized Illustrations)

Graphic	Name and Meaning	Shape	Remarks
$	Applying Price	Dollar Sign	
+	Adding	Plus Sign	
√	Checking	Check Mark	

Database

The database of tool patterns used a specific data form with data units that provide blanks for condensed information about each component of a tool pattern for presenting summarized tools as easily understandable and usable patterns. The data form was designed in three parts: a general summary of tools, application to interior design, and sources of information (Figure 2). The data form consists of seven data units: a name, a general description, a guideline for use, an illustration, applicable steps of the interior design process, a note for use in interior design, and documentation of all sources. All of the information for the 20 design methodological tools selected is presented in the database, a copy of which is included as Appendix 3.

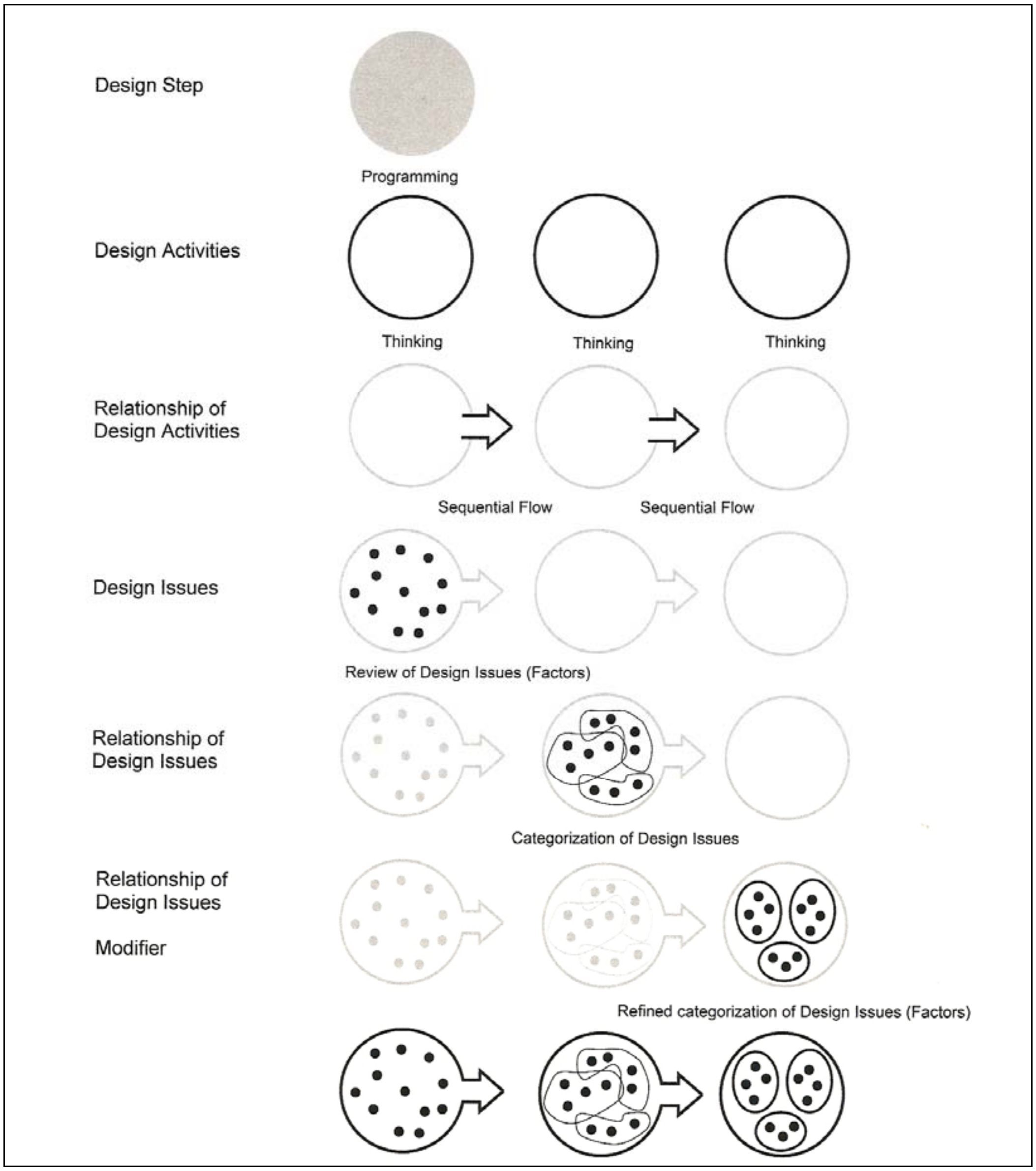
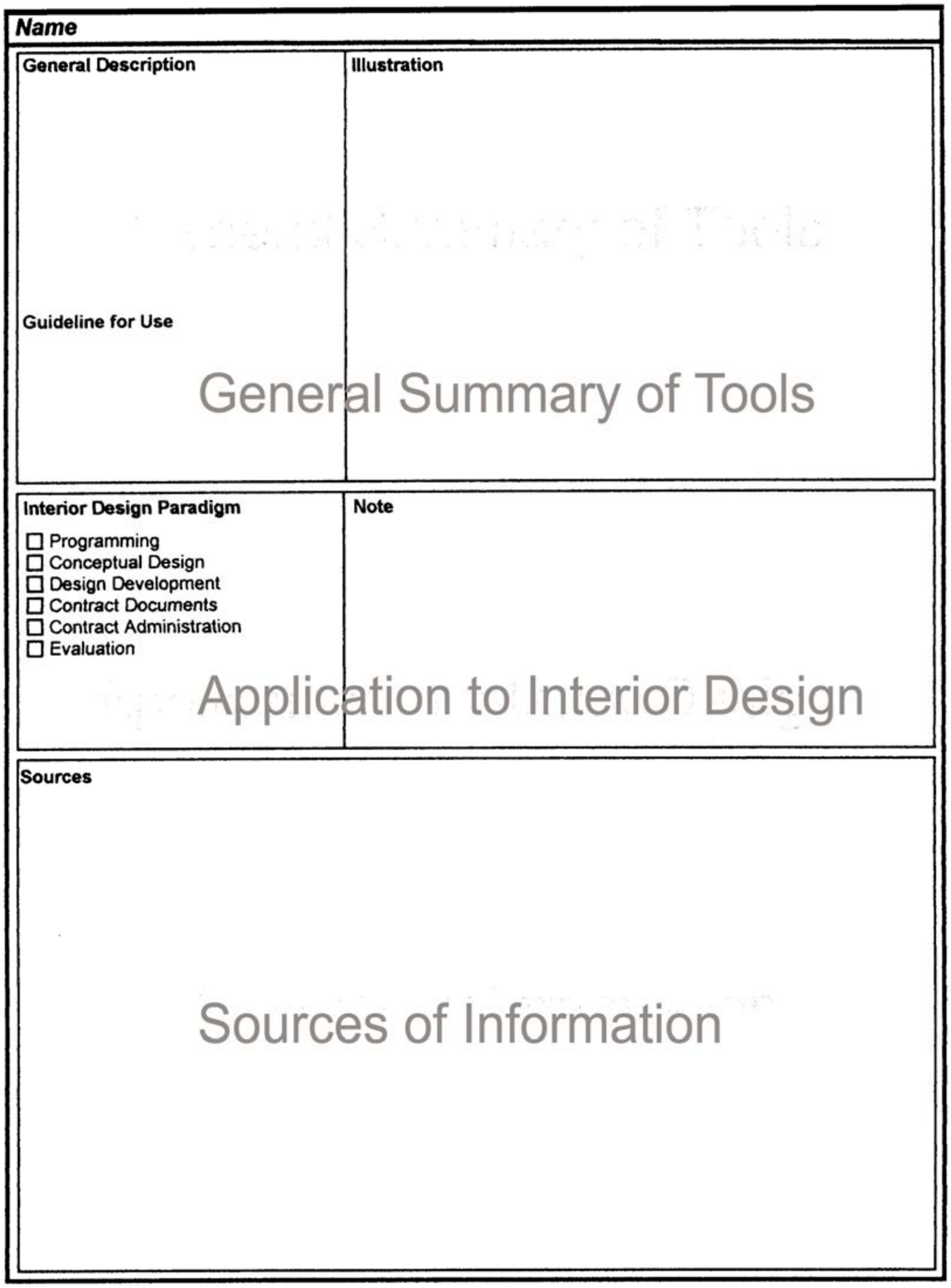


Figure 1. Illustration Development, "Classification of Factors" Tool.



Name

General Description	**Illustration**
Guideline for Use	
General Summary of Tools	

Interior Design Paradigm	**Note**
☐ Programming ☐ Conceptual Design ☐ Design Development ☐ Contract Documents ☐ Contract Administration ☐ Evaluation	
Application to Interior Design	

Sources

Sources of Information

Figure 2. Data Form.

Brainstorming 1

General Description

A group of people produce many ideas quickly without criticism. Brainstorming raises the quality of ideas as well as the quantity. Group members should trust each other to speak everything in their minds. The vauable output is not ideas themselves but the categories into which they are placed by classification.

Guideline for Use

1. Select people.
2. Produce ideas. (without criticism)
3. Improve the ideas.

Illustration

Interior Design Paradigm

- ☒ Programming
- ☒ Conceptual Design
- ☒ Design Development
- ☐ Contract Documents
- ☐ Contract Administration
- ☐ Evaluation

Note

Example of Brainstorming for Door types
swing door, revolving door, sliding door, folding door, flush door, automatically opening door, panel door, air curtain, fabic curtain, no wall, beads, doorkeeper...

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Figure 3. Data Units.

The capability of a database to store, retrieve, and sort information provides easy access to and exchange of information about each tool. FileMaker® Pro software provides access to text data via key words under the 'find' command. Data can be sorted using any key words contained in data units. For example, in the data unit box labeled 'interior design paradigm,' if the user selects the box of 'programming,' the tools for programming are sorted. Also, the database is easily updated because the information in data units is easily revised. Although the database for this study was developed for use by interior design students and practitioners, other design disciplines could modify the database by creating new data units for their own applications and needs.

Additional Research

While this study introduced a database of tool patterns for interior design students and practitioners, several issues were suggested for further study. Based on the introduction of the composition of tool patterns for interior design, other design disciplines might develop compositions of patterns for introducing their tools and adding data units to their databases. This study provided a general summary of tools and their applications but did not address the time and energy needed for using the tools. A data unit that deals with this information might help further the understanding of tools. The current compactly-designed layout of the database allowed entire units to be printed on a sheet of paper. However, a revised layout would be required if extra text information was added. To create a reference of design methods that can be widely applicable for simple and complex design projects of diverse disciplines, tools from multiple disciplines should be added. Such a database could be expanded into one that covers broad and varied applications for the future.

The illustrations of tool patterns were presented in a cohesive and meaningful graphical format. A new data unit that presents the illustration components might provide quick and direct understanding of the illustrations for each tool, saving the time and effort required to find the meanings of illustration components at their lists. The illustrations of tool patterns were intended to enhance understanding of tools. A research study could be designed to test the effectiveness of the illustrations of tool patterns. An experimental group could be taught about tools with the illustrations, while a control group could be taught about tools without the illustrations. The progress of both groups would be noted.

Conclusion

This study attempted to provide a uniform method for the use of tools to enhance interior design students' and practitioners' familiarity with and efficiency in using them. The computer database of tool patterns was developed to achieve this. To develop the database, ten common tools were selected from the DMG and ten interior design tools were selected from the NCIDQ. Finally, the information about tool patterns was put into the database to convey the information in an easily understandable and quickly retrievable form. More studies about methodological exploration and utilization will be necessary to further develop an interdisciplinary body of knowledge in design methods.

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Editor's Note: Interaction can facilitate learning, and technology has the potential to simplify access. Ubiquitous technologies become natural interfaces for learning and communication. This pilot study appears to integrate these functions for successful learning.

Bridge the Virtual Gap: Using New Technology to Enhance Interaction in Distance Learning

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USA

Abstract

Interaction is important to effective learning. Moore (1989) defines three types of interaction: learner-content interaction, instructor-learner interaction, and learner-learner interaction. With the advancement of telecommunication technologies, Hillman, Willis, and Gunawardena (1994) add another type of interaction that learners need to succeed in distance learning: learner-interface interaction. Survey data from an Internet protocol television (IPTV) class were analyzed based on this framework of interaction. The study found that the new software used on the tablets enhanced the four types of interaction and made learning more fun and engaging to the students.

Keywords: distance learning, interaction, Internet protocol television (IPTV), DyKnow, mobile computing, tablets, laptop, chat, polling, constructivism

Introduction

DyKnow is educational software designed to engage students in learning in a pen-enabled environment. Standing for dynamic knowledge transfer, DyKnow originated from an idea of David Berque, a professor of computer science at DePauw University. Its intent is to switch students' focus from copying notes in the classroom to understanding the learning content and to increase collaboration with the instructors and other students in a pen-enabled environment. It can be also used on a laptop or desktop with limited functionalities.

DyKnow software includes two parts: *DyKnow Vision* and *DyKnow Monitor*. *Vision* is a teaching and learning tool while *Monitor* is a classroom management tool used to control and reduce electronic distraction in the mobile learning environment. To implement this software, an institution needs to buy the server license, which enables the live synchronous sessions and access to the notebooks on the server.

DyKnow can do many things to enhance teaching and learning. For example, an instructor can transmit learning content to student computers for annotation, which can thus save note-taking time and allow students to focus on understanding the learning content. Moreover, an instructor can ask students to collaborate on a shared whiteboard and give shared whiteboard control to one or more students. As the student presents, the teacher and other students can see the presented content on their individual computers. Additionally, DyKnow has some other features such as polling and chat which enhance online communication.

Sponsored by the Provost's Office, Fort Hays State University in Hays, Kansas started a DyKnow pilot project during the summer of 2006. To represent distance learning classes, an Internet protocol television (IPTV) class was selected to participate in the pilot. This class was a four-week summer course in the area of special education and included 12students: six students on campus and six students at two remote sites with three students at each site. All the students used tablets from a mobile cart provided by the University, and the instructor delivered tablets to the students at the remote sites. All the students were restricted from taking the tablets home and could only use them during the formal class sessions.

Literature Review

Learning should be an active process in which interactivity is encouraged (Northrup, 2001). Vrasidas and McIsaac (1999) define interaction as “the process consisting of the reciprocal actions of two or more actors within a given context” (p. 25). Keegan (1996) thinks of interaction as the key to effective learning and Moore (1989) considers interaction “a defining characteristic of education” (p. 2).

Interaction has a variety of functions in the educational process, and the value of other people’s perspectives, which can be often gained through interaction, is a key component in constructivist learning theories (Jonassen, 1992). In addition, interaction is critical to creating the learning communities advocated by Lipman (1991) and Wenger (1998) who focus on the critical role of community in learning. Moreover, Sims (1999) argues that the word “interactive” implies “better experiences, more active learning, enhanced interest and motivation” (p. 257). He has listed dimensions of interactivity to demonstrate the multi-faceted nature of interaction. These dimensions include such functions as allowing for learner control, learner participation and communication, facilitating program adaptation based on learner input, and developing meaningful learning for learners. Chickering and Ehrmann (1996) sugegst seven principles of good practice with computers and telecommunication technologies, and four of them are related to interaction: encouraging contacts between students and faculty; developing reciprocity and cooperation among students; using active learning techniques and giving prompt feedback. These principles emphasize the interaction between students as well as between teachers and students.

Moore (1989) outlines three types of interactions that have become a framework for the study of interaction: *learner-content interaction*, *learner-instructor interaction*, and *learner-learner interaction*. *Learner-content interaction* is defined as “the process of intellectually interacting with content that results in changes in the learner’s understanding, the learner’s perspective, or the cognitive structures of the learner’s mind” (Moore, 1989, p. 2). It refers to the process in which learners process the course information for their own knowledge understanding and knowledge construction. *Learner-instructor interaction* is communication between the instructor and the students in a course, and attempts to stimulate and motivate learners to learn with the instructor’s facilitation for understanding the content in the learning process. *Learner-learner interaction* is communication between one learner and another learner with or without the real-time presence of an instructor. In distance learning, instructor-learner interaction and learner-learner interaction often occur via computer-mediated communication although it may include other forms of interpersonal communication, online or offline, which occurs during the duration of a course.

Hillman, Willis, and Gunawardena (1994) have added another type of interaction in the electronic learning environment: *learner-interface interaction*. This type of interaction is defined as “process of manipulating tools to accomplish a task” (p. 34). They remarked: “When dealing with any tool, it is necessary for the user to interact with the device in a specific way before it will do his or her bidding” (p. 34). Learner-interface interaction refers to the interaction between the learner and the technological medium while the learner interacts with the content, instructor, or other learners. Learners who do not have the basic skills required to use a communication medium spend more time learning to interact with the technology and have less time to learn the course content. Therefore, it is important for students to learn how to use the mediating technology in distance learning.

Data Collection

Both quantitative and qualitative data were collected through an online survey conducted with the students and the instructor after the IPTV course was completed. The instructor sent the online survey to the students via e-mail and asked them to complete it by a certain date. A 28-item survey was sent to all the students and a 32-item survey was sent to the instructor. The questionnaires included multiple choices items, Likert-scale rating, and open-ended questions. The items were rated from 1 to 4 on a Likert scale (1 = strongly disagree, 4 = strongly agree), with 4 being the highest.

Data Analysis

Nine out of 12 students completed the survey, with a response rate of seventy-two percent. Among the survey participants, seventy-five percent were seniors and twenty-five percent were juniors. All of the students were female and Caucasian Americans. Most of the students were non-traditional students: twelve percent were 26-30 years old, forty-four percent were 35 or above 35 years, and the reminder were 20-25 years old. About eighty-nine percent of the participants used DyKnow only during the class and eleven percent used it both during the class and at home on their own computer. About fifty-six percent of the participants used DyKnow ten hours per week, and thirty-three percent used it five hours per week, with eleven percent using DyKow 15 hours per week. All of the participants used DyKnow on a tablet and it was the first time for all the participants to use DyKnow in a class. Students used all the primary features of DyKnow Vision, including note-taking, content sharing, re-play, chat, and private notes. The top three features students used in the class were note-taking, chat, and private notes.

In the IPTV class students can hear and see the instructor at remote sites. While using DyKnow software and tablet PCs, students and instructor liked the new technology and enjoyed the new learning and teaching experience. In the following section, the data are analyzed based on four types of interaction: learner-content interaction, instructor-learner interaction, learner-learner interaction, and learner-interface interaction.

Learner-content interaction

Learner-content interaction is an internal process for learners to transform the information passed from another, and construct it into knowledge with their own personal understandings and applications. Students learn and process the learning materials for knowledge construction through many ways such as reading, listening to a lecture, note taking, doing a project, and writing a paper.

Table 1

Learner-Content Interaction

Items	Mean	1	2	3	4
Using DyKnow made learning more fun	3.44	0%	22%	11%	67%
Using DyKnow facilitated my learning	2.56	0%	44%	56%	0%

According to Table 1, most students (eleven percent agreed and sixty-seven percent strongly agreed) thought that it was fun to use DyKnow in learning. Most of them (fifty-six percent) also thought that DyKnow software facilitated learning for this course. Some qualitative data derived from answers to the open-ended questions also demonstrated that DyKnow helped students to learn the content through more personal presentations, enhanced note taking, easier access to the instructor and classmates' feedback and better ways of reviewing notes and learning materials. In general, students expressed that the new technology tool made their learning more engaging, personal and interactive.

When talking about what they liked most about DyKnow and how DyKnow helped them in learning, students commented:

- "I liked the fact that the teacher could share her PowerPoint on the tablet. This makes it easier for the ITV students to see the PowerPoints."
- "I liked Dyknow because you could listen to the instructor, follow along with the PowerPoint and take notes (by either typing or writing them down). I really liked the pen, this made taking notes much easier, especially if the instructor shows you a chart, you can easily add it to your notes in one convenient place."
- "I really liked having the PowerPoint presentation in front of me instead of on a TV screen. It seemed more personal when the teacher was writing on the screen instead of just reading it."
- "It makes learning more interactive and personal.… You can save your notes to study from later, plus have input from the instructor and other students to look at."
- "I liked that the teacher was able to put up the notes and make her own notes on the slides and we were able to see them right in front of us."
- "I liked drawing on the slides truthfully. I doodle when taking notes, and it was fun to add color to the slides through the pen function and the highlighters. It was also nice to be able to write it on my own instead of typing notes. I learn through actually doing something, so using the pen was nice."
- "One of the advantages that I felt using DyKnow was that I was able to see when the instructor was making an important part on the PowerPoint because she would underline or highlight this information and there it was right in front of you! There was no distractions at this point and time."
- "The PowerPoints were easier to use and I took better notes because I liked the feel of the pen on the tablet."
- "I liked using the tablets to follow along with the lectures. It helped me organize my notes much better than if I write them down. I have problems going back and reading my written notes at times, especially when I write them fast. I can usually type faster than I can write."
- "I liked the fact that I could listen to the lecture without having to write everything down."

Instructor-learner interaction:

Instructor-learner interaction refers to the communication between the instructor and the students in the learning process. Traditionally, this type of interaction is primarily initiated by the instructor rather than the students. The instructor initiates communication with students by ways such as giving lectures, asking questions, providing assignments, and offering feedback on assignments. However, DyKnow is unique in that it enables another direction of interaction that is initiated by the students and the instructor. Students can easily ask questions, demonstrate projects, make comments, and express confusion or misunderstanding via DyKnow features such as chat, whiteboard sharing, polling, and participant status.

According to Table 2, most of the students thought that using DyKnow enhanced interaction with the instructor (forty-four percent agreed and thirty-three percent strongly agreed).

Table 2

Instructor-Learner Interaction

Items	Mean	1	2	3	4
Using DyKnow enhanced my interaction with the instructor	3.11	0%	22%	44%	34%

In answering some open-ended questions, students commented:

- "I liked the interaction between the instructor and students."
- "I also liked the fact that I felt more connected to the other sites, because we were able to see the instructor as she wrote on the notes."
- "It's very visual and hands-on and more personal with the instructor and other students."
- "I really liked having the PowerPoint presentation in front of me instead of on a TV screen. It seemed more personal when the teacher was writing on the screen instead of just reading it."

From the instructor's perspective, data revealed that using DyKnow enhanced interaction among the students as well as between the instructor and the students. The instructor also agreed that using DyKnow helped provide timely feedback to the students.

When talking about how DyKnow helped her in teaching, the instructor said: "DyKnow helped me to establish a true learning community much quicker and easier. For example, it allowed immediate access to class members' thoughts (as well as their personal hand-written writing styles), and thus, added an additional visual element to student's verbal discussions."

Learner-learner interaction

Learner-learner interaction is the communication among students, alone or in a group setting. Traditionally, this type of interaction is neglected in distance learning. With features such as content transfer, whiteboard sharing, and chat, Dyknow makes it possible and easy for the students to share ideas, view sample assignments, and peer review projects.

Table 3

Learner-Learner Interaction

Items	Mean	1	2	3	4
Using DyKnow enhanced my interaction with classmates	3.22	0%	11%	56%	33%

The survey data in Table 3 show that most students thought that using DyKnow enhanced their interaction with classmates (fifty-six percent agreed and thirty-three percent strongly agreed). Some students also commented on their experience regarding this type of interaction:

- "I also liked the fact that we could still chat with the IPTV students if we lost our visual connection."

- "The advantage of Dyknow in this class was the ability to use the chat feature. Many times we lost our bridge connection through the IPTV, so we were able to chat with the instructor and other students. This was great, because we didn't miss out on anything going on in class and they did not have to wait on us to get connected again to resume class."

The instructor remarked on her experience in using DyKnow software in her IPTV class:

In my IPTV class, one of the advantages of using DyKnow was that it allowed students to communicate via their tablets over hundreds of miles. For example, once when there were Internet problems and students from remote sites were unable to be heard or seen, it was still possible to communicate via the chat feature of DyKnow...totally cool! Also, when completing team projects, the students could submit their panels and teams from sites "across KS" could see what had been submitted by their peers.

Learner-interface interaction

Learner-interface communication indicates that students need to learn how to use a technology tool in the electronic learning environment. Their skill in handling the mediating technology directly affects their capability to interact with the content, the instructor, and the classmates. In the early stage of distance education, the instructor only needed to mail the learning materials to the distance learners and the students mailed their assignments back to the teacher. Communication at that time was primarily performed via paper, pen and mail. With the advancements of technology and telecommunications, students need to know how to handle the mediating technology tools in order to succeed in a distance learning course.

Table 4

Learner-Interface Interaction

Items	Mean	1	2	3	4
Using DyKnow was very frustrating	2.25	25%	38%	25%	13%
Using DyKnow was a waste of time	1.89	22%	67%	11%	0%
I enjoyed using DyKnow in my study	2.89	0%	22%	67%	11%

According to Table 4, most students thought it was not difficult to learn the new tool on tablet PCs. Twenty-five percent of students strongly disagreed and thirty-eight percent of students disagreed that using DyKnow was frustrating in the learning process. Most students thought it was necessary to learn Dyknow (twenty-two percent strongly agreed and sixty-seven percent agreed). Most of them also enjoyed using DyKnow in their study (sixty-seven percent agreed and eleven percent strongly agreed).

Conclusions

It appeared that the instructor and the students enjoyed using DyKnow software and tablets in the IPTV class. They thought it was fun to do teaching and learning in a new way, and in particular, the IPTV students really liked the chat feature as it helped them to connect with the instructor and students at other sites when they lost the bridge connection.

Although the pilot class was only four weeks in duration, which is a short period of time for applying a new tool, both quantitative and qualitative data show that DyKnow functionalities enhanced the four types of interaction in the IPTV class and made learning a more fun experience. All the students were white female Americans with fifty-six percent of them were non-traditional. More investigation is needed in this area with a more diverse population and longer course duration.

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