Effectiveness of an Interactive Application to Assist Learning: A Test Case

Raafat George Saadé
Dennis Kira
John Molson School of Business
Decision Sciences and Management Information Systems
Concordia University
Montreal, H3G 1M8, Canada
rsaade@jmsb.concordia.ca dkira@jmsb.concordia.ca

ABSTRACT

Advances in computer technologies have made it possible to develop computer-aided learning tools for enhanced learning. Today, most researchers in the field of educational technology seem to be preoccupied with either the development of Artificial Intelligence applications or the representation of various learning theories such as constructivism by a computer program. The enthusiasm to develop technologically advanced learning tools resulted in technologies with limited application. The need to develop simple computer-based tools to assist instruction and demonstrate its effectiveness to enhance learning is paramount. Moreover, those tools need to be designed and integrated into a pedagogical framework. As a result, the instructor transforms into a content facilitator with altered needs. This paper presents the design and use of an interactive computer-aided learning tool for enhanced learning. Two participant groups were randomly selected. One group was allowed to use the interactive computer-aided tool prior to a test, while the second group was not. Performance of the groups was compared. Results revealed a higher mean test score for group one. The impact of the tool on test scores was found to be significant. The findings have direct implications on the design, development, testing and implementation of interactive computer-aided learning tools and on today's transforming roles of educators and learners.

Keywords: Interaction, Learning, Computer-Aided, Education, Application, Learning Tools

1. INTRODUCTION

The last decade has witnessed significant change in the development and use of information technologies. The education sector has to accommodate the ever-changing student population. Considering that the staff employed in educational institutions has remained relatively the same and the resource support to develop new courses has decreased, the quality of the learning experience is at risk of being diminished (Parkinson and Hudson, 2002). Advances in computer technology provide an opportunity to support the learning process. This opportunity includes the development of computer-based interactive resources that can be consistent with contemporary educational theories (Dalgarno, 2001a).

A lot of research in education is concerned with the development of: (1) Artificial Intelligence (AI) applications such as Computer-Aided Instruction (CAI); Intelligent CAI; Intelligent Tutoring System (ITS); and Intelligent Learning Environment (ILE) (Felder, 1993 and Howard, Carver and Lane, 1996), and (2) applications that can be justified as being consistent with educational theories. There is also a new trend of research which deals with comparing the performance and attitudes of students taking online courses versus those taking lecture-based courses (Davies, 2003, Sunal et al., 2003, O'Regan, 2003). It seems that advancements in the use of technology for educational purposes have bypassed two major elements: (1) the integration of computer-based applications in the instructional process and vice versa, and consequently (2) the transforming role of the instructor.

Learning involves many factors that interact with each other to build knowledge. The interactive process recognizes that learners acquire data, assimilate the data, and transform the data into knowledge. The results of this data transformation depend on how the learner interprets the data and information received and by attributing meaning to them on the basis of existing knowledge. Computer-aided tools can be designed and developed to help learners in the learning process (Moore, 1989). However students and instructors alike, need to adapt to the rapid changes in the technology knowledge-base

environment. More importantly, instructors need to update their technology knowledge-base in order to develop and maintain a continuous computer-aided learning environment. It is therefore suggested that computer applications should be integrated into different learning strategies and those applications in turn should be designed to not only be consistent with contemporary learning principles but also include some level of pedagogy. If the learning strategy fails to provide these elements, then it will not be effective.

While many perceive online computer-aided learning tools a major breakthrough in teaching and learning (Hill, 1997), many educators and trainers do not support it (Conlon, 1997). Although the growth of online computer-aided learning tools has been significant recently, there still exists a major gap in the design and evaluation of their educational (teaching and learning perspectives) capabilities and effectiveness in enhancing the learners' experience (Saadé, 2003).

2. RESEARCH QUESTIONS

Today, the term 'computer-assisted learning' is used loosely to represent the utilization of any application for delivering content to the student. This may be electronic material that students would read or interactive learning tools to help learning. Concerns currently being explored by researchers include student attitudes, course design and delivery, course evaluation, and instructor behavior and attitudes (Sunal et al., 2003, Achtemeier et al., 2003, Richardson and Swan, 2003, Dutton et al., 2002, Picciano, 2002). The effectiveness of computer assisted learning applications and the utilization of well-developed research plans are relatively scarce at this time (Sunal et al., 2003). This study was motivated by the need to evaluate the use and effectiveness of computer-aided learning applications as they are used in the instructional environment.

In this paper we present an interactive computer-aided application whose primary objective is to assist students in learning. Lockard et al. (1994) identified two types of computer-aided learning and teaching systems namely, type 1 that involve the use of computer resources (such as word processing and spreadsheets) to do isolated activities without the aid of a computer program and type 2, that includes applications that use computers to enable teaching and learning in ways that were not possible with conventional approaches. The application in this paper can be considered as type 2 applications. The major research questions that guided this study are:

1) **Does the application have a measurable effect on student learning?** This research question was addressed by giving two groups of students the same test. However, only one group of students used the application prior to the test. Student learning here was measured by their test scores (Performance).
2) **What is the impact of the application usage on student performance?** In other words, we seek to investigate if there are any usage-performance associations. While using the application, the score and the time of a complete interactive session were measured. This enabled the investigation of possible association between student's time to complete a session and corresponding application scores.

3. THE APPLICATION: PROCESS, DESIGN AND PEDAGOGY

The application described in this paper is aimed at university/college level students. Its primary objective is to allow the student to explore different perspectives to concepts by manipulating related information. The aim of the exercise is to provide the student with an opportunity to construct his/her own mental model of a specific concept. This objective has some elements of the constructivist approach (Dalgarno, 2001b) and entails the implementation of learning strategies designed to involve the student in the learning process as well as a relatively high level of interactivity with instantaneous feedback.

Providing immediate feedback was shown to increase the rate of learning (Lhyle and Kulhavy, 1987). Effective feedback provides the learner with two types of information: (a) the verification of correct answer and more importantly, (b) the elaboration by providing clues to distinguish the correct answer (Crippen and Brooks, 2002). The computer-aided application used in this study provides both immediate and effective feedback.

The application was developed so that students could practice and assess their knowledge of content material and concepts specific to a subject matter. Although the application was developed for the web, it was used in a computer lab. The application was not used via the internet/web because it was the first running version and it was important to be able to intervene and correct any bugs that might arise. In effect, a technician was available to resolve any problems instantly.

In using the application, students rehearse concepts specific to a subject matter by having the application prompting them with multiple choice, true or false and fill-in-the-blanks questions as shown in figure 1 below. In figure 1, the rectangle represents the student-application interface while the ovals represent processing by the application.

The rehearsing process entails a double randomization procedure, one at the type of question level and the other at the actual question level. After logging into the main page of the application, the student selects which specific concept he/she wishes to rehearse. The application now knows which questions data set it needs to use. The application then starts to record the time starting from zero. First, the application identifies what type of question to ask the student (i.e. multiple choice, true or false or fill-in-the-blanks question). This is done using a random function. Once the application has selected a type of question to ask,

it then selects from a pool of related questions also using the same randomization function. The student answers the question; the time to answer the question is logged and feedback to the answer (correct or incorrect) is given to the student. Another question is then selected by the application using the same procedure described above and is prompted to the student again. This session of questioning continues until the time specified for rehearsal is completed after which the student is given a detailed performance report (running averages broken down per type of question) and an overall performance score.

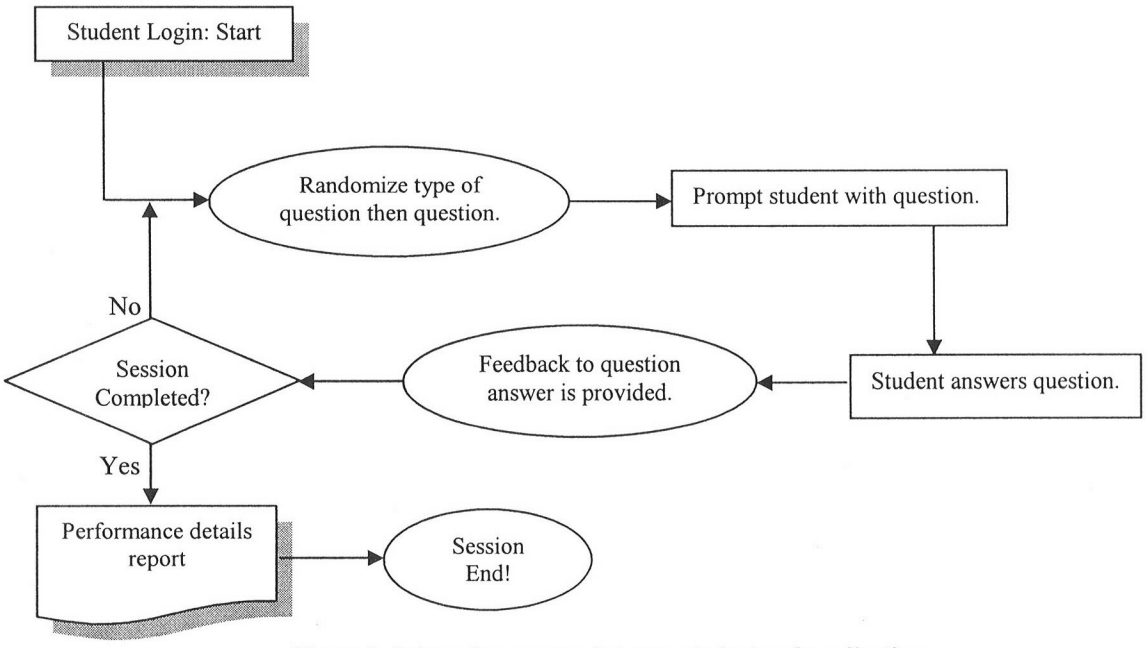


Figure 1: Interaction process between student and application.

The application design features some important pedagogical elements whose aim is to involve the student more intimately with the subject matter being studied. These features are:

1) All questions target a very specific concept. That is, the application is designed and is being tested for concepts specific to a topic. The knowledge that a student is being tested on is domain specific. Examples (if we consider databases) include concepts such as: data and information; the data modeling concept, and the associative entity.
2) The pool of questions includes a fixed number of multiple choice questions, true or false and fill in the blanks. The reasoning behind this is the intentional repetition of questions which targets recollection and short-term memory.
3) The multiple choice questions establish the scope of knowledge that is to be learned.
4) The true or false are hints to the multiple choice questions and are equal in number. Students are told of this design feature prior to using the application in an attempt to increase their attention during the on-going interactive session.
5) The fill-in-the-blanks questions are composed from the multiple choice questions but phrased differently.

Presently, the design of the application includes a total number of 30 questions per concept. Out of the 30 questions, 10 are multiple choices, 10 are true or false and 10 are fill-in-the-blanks. It is important to note that the application does not present the student with a list of the randomly selected questions. In fact, the student is prompted with one question at a time. So a student for example may take 25 seconds to answer a question while another may answer the same question in 10 seconds. On the other hand, a student may take 8 seconds to answer true or false questions and 40 seconds to answer a multiple choice question.

The student may also be prompted with the same question multiple times during one interactive session. In effect, the total number of questions a student ends up rehearsing is not known and varies among students.

This design which allows the repetition of questions and the fact that true or false questions are hints to the multiple choice questions promote the use of short-term memory, recognition, and recollection skills. A second attempt to answer a question reinforces the students' understanding of the question and of the concept at hand regardless of the outcome of the question the first time it was answered. The innovative possibilities of this application design in terms

of assessment and learning are discussed in the conclusion section.

4. METHOD

4.1 Subjects

This test case examined the impact that the application may have on learning. Two groups were used from two different semesters due to the limited number of students taking the course. Students were enrolled as part of the MIS curriculum at John Molson School of Business, Concordia University, Montreal, Quebec, Canada. The course is a 300 level course (introduction to database management) with the students being in the second or third year of their program. A total of seventy-four (74) students participated in the study.

The course in both sessions, was taught by the same instructor, delivered in the same department, and included the same assignments, notes, book, activities and projects. The two groups were used to compare their performance. It is important to consider for this type of comparison study the equivalence of the groups. Demographics data were limited due to privacy and included gender and age. These were reviewed and the differences were non-significant.

4.2 Procedures

The test case was conducted during two consecutive semesters. In the first semester a group of 37 students (group 1) participated. One week prior to the midterm test the students were asked to use the application at their convenience. The midterm test was then administered. During the following semester the other 37 students (group 2) taking the same course, were given the midterm test without having them use the application. For both groups, the test topics, week at which the test was administered from the beginning of the session, and time allocated to the test were the same. Both groups had access to the same questions and which were discussed in class.

From an ethical perspective, if the two groups of students were in the same semester, then ethics would be an issue since one group may have had an advantage on the other. In the present case, the entire class in each semester was treated the same and discrimination was avoided.

4.3 Instrumentation/Measurements

Recall, the major research questions for this study were: (1) Does the application have a measurable effect on student learning? and (2) What is the relationship between the application usage and performance? In order to compare the difference in performance between the two groups, averages were computed first. Then regression analysis was performed to examine any usage-performance associations. The variables captured were time in minutes, scores for the application, and scores for the test.

5. RESULTS

This study is consistent with prior research where interactive computer-based instruction was been shown to positively impact student learning (Wegner, Holloway and Garton, 1999). The results of this study are also consistent with previous research suggesting that students who use quizzes score higher in exams than those who use traditional study methods (Hall, Pilant, and Strader, 1999). Table 1 presents the performance statistics for both groups. There is a clear indication that group 1 performed better than group 2 on the test. This indicates that the application influenced student learning. This enhanced learning is reflected in the mean score and indicated a difference of 14%.

Table 1: Performance Statistics.

Sample	Min	Mean (SD)	Max
Application Session	48	61 (5.7)	78
Group 1: With application	46	75 (11.0)	94
Group 2: No application	35	66 (12)	82

It is interesting to note that the mean application session score of group 1 is less than the mean test score by approximately 19% and 7.5% for group 1 and group 2 test scores, respectively. Student performance was worse during the application session, but not without benefit. The means suggest that the use of the application influenced learning.

To examine usage-performance associations, correlation and regression analyses were performed. A correlation analysis was performed on the application and test scores for group 1. The value of the Pearson correlation coefficient shows the strength of the linear relationship as well as its direction. The p-value produced provides a handy measure of meaningfulness of the relationship. Running a correlation analysis between the application and group 1 test scores, results in a Pearson correlation of 0.921 and a p-value equal to 0.000. This result implies that the application scores and group 1 test scores correlate well. The p-value implies that there is a high probability that we would observe a strong linear relationship (0.921). After exploring the correlation between the application and group 1 test scores, the relationships among the application session time, the application scores, and test scores for group 1 were examined using linear regression. Table 2 presents the regression analysis results used to investigate the influence of the application usage on student's performance in a following test. In the table:

- The dependent variable (y) is the scores of the test (a) and the application scores (b).
- The independent variable (x) is the application score (a) and the application session time (b).
- β represents the regression coefficient describing the amount of change in y per unit change in x, and β_0 is the y-intercept,
- t, which is the statistic for determining whether the x-y relationship is statistically significant.
- p, is the statistical significance of the test and

- R^2 is the percentage of variance explained by the variable tested in the sample.

Table 2: Regression Results (group 1: ICALT prior to test)

y	x	β_0	β	t	p	R^2 %
(a) Test Scores	App. Scores	0.096	0.030	14.37	<0.001	85
(b) App. Score	App. Session Time	14.90	0.145	8.95	0.428	2

Overall, linear regression results confirm that there is a strong positive relationship between the application scores and test scores for group 1, with standardized path coefficients equal to 0.030. This relationship is highly linear with an R^2 of 85%. Regression analysis does support a causal relationship between application scores and test scores, and shows that the association between the application session time and application score is not significant ($p = 0.428$) and not linear ($R^2 = 2\%$). The results suggest that time spent using the application does not have an impact on application score. (a) and (b) together therefore seem to imply that the process of using this application for learning is more important than the application score itself. It seems that when it comes to application session time, other variables are involved.

6. DISCUSSION

The present study explores the impact of an interactive computer-aided application on learning. The use of the term 'learning' was used loosely and most times is measured by performance. Its use in the context of this study has implications to the design of the computer-aided tool which promotes student development of mental models. The study included two groups where only one was given the application to use prior to the test. Results were consistent with prior research showing the positive impact of computer-aided tools on student learning and those suggesting that students who use quizzes score higher in exams than those who use traditional study methods.

The ultimate question for educators and practitioners is how to develop, test and implement computer-aided learning tools to maximize learning opportunities, and enhance the learning process. Maximizing learning opportunities and enhancing the learning process requires the following:

1) Integrating the computer-aided learning tool into the instructional strategy, and
2) Designing the computer-aided leaning tool with pedagogy in mind.

In this study, the design of the questions is very important. The scope of a concept (within a subject matter) to be learned is first specified by the 10 multiple choice questions. The 10 true or false questions and 10 fill in the blanks questions are created directly from the 10 multiple choice questions. While using the application, immediate feedback is provided. Effective feedback is integrated into the activity by having the true or false question as a hint to a multiple choice question. In other words, each multiple choice question has an associated true or false question as a hint. Finally, each fill-in-the-blanks question is also associated to the each multiple choice question, further reinforcing the knowledge to be learned. From the application perspective, the randomization process, presents the students with a challenge to carefully read the multiple choice questions and pay attention to the true or false and fill-in-the-blanks questions, all under time constraint. This process promotes increasing student attention and hence learning. In effect, students would like to answer correctly as many questions as possible in a single session.

Based on the present research and previous literature, computer-aided learning tools similar to the one presented in this study should be developed and further tested. Some suggestions are presented below.

7. LIMITATIONS, IMPLICATIONS AND SUGGESTIONS FOR FUTURE RESEARCH

Implications are confined to the limits of their interpretation and must be acknowledged. Limitations to the present study are primarily with respect to the student participants:

- The fact that the two groups of students were from different semesters may require a more detailed analysis of their background and demographics, such as gender, age, ethnicity, computer skills and grade point average.
- This study did not analyze the student knowledge-base prior to the teaching of the content. One group may have had better prior knowledge of the content than the other, which may have an influence on learning effectiveness.
- From the analytical perspective, the sample size is not large enough for the results to be deemed conclusive; however, the results present a good indication on the impact of the computer-aided learning tool on performance and the impact strength.

In view of these findings, several implications emerge. First, the application design from both a pedagogical and instructional perspectives is interesting. It extends the simple multiple choice rehearsing approach to cognitively involve students by increasing their attention during the interactive session. In that respect, further effort is required to investigate the cognitive absorption of the learner while using the application, especially that cognitive absorption has been shown to enhance learning (although research in this is still limited). Second, the application can include different learning strategies to meet different learners needs (gender, age, culture, learning style) with a pre-

assessment module to evaluate the best strategy for the students' optimum learning. Therefore, a better understanding on the effects of different cultures, age groups, gender, and learning and cognitive styles is needed so that specific strategies for enhanced learning can be developed. Finally, educational practitioners need to work slowly but surely in the development of interactive computer-aided learning tools and thus need to be familiar with the limitations and capabilities of not only the learning background but of the underlying technologies.

This is necessary because interactive computer-aided learning tools do provide effective support in the classroom and benefit both the educator and learner. It is an integral part of the transforming role of the instructor. The instructor cannot anymore push content in the classroom. The instructor needs to develop other talents: be computer savvy, be creative, have the ability to design instructions based of different course characteristics, integrate technology in the instruction process, be able to design and develop specialized applications and understand human behavior such as student's perceptions, attitudes and computer competencies. The instructor's role is transformed from a content provider into a content facilitator. Traditionally, there was one mode of content delivery (instructor) for all the different students. Today, the instructor has the capability and needs to acquire the ability to transform in different ways to the different way students learn. This opportunity is possible by focusing on the design of the computer-aided leaning tools and their integration into the instructional plan.

8. REFERENCES

Achtemeier, D. S., Morris, V. L. and Finnegan, L. C. (2003). Considerations for Developing Evaluations of Online Courses. *JALN*, 7, 1, pp. 1-13.

Conlon, T. (1997). The Internet is Not a Panacea. *Scottish Educational Review,* 29, 1, 30-38.

Crippen, J. K., and Brooks, W. D. (2002). An analysis of Student Learning at a Testing Web Site Emphasizing Descriptive Chemistry. *JI. Of Computers in Mathematics and Science Teaching*, 21, 2, 183-201.

Dalgarno, B. (2001). Technologies Supporting Highly Interactive Learning Resources on the Web: An Analysis. *JI. Of Interactive Learning Research*, 12, 2/3, 153-171.

Dalgarno, B. (2001). Interpretation of Constructivism and Consequences for Computer Assisted Learning. *British Journal of Educational Technology*, 32, 2, 183-194.

Ewing, M. J., Dowling, D. J. and Coutts, N. (1998). Learning Using the World Wide Web: A Collaborative Learning Event. JI. Of Educational Multimedia and Hypermedia, 8, 1, 3-22.

Davies, Randall S. (2003), "Learner Intent and Online Courses," *The Journal of Interactive Online Learning*, Volume 2, Number 1, Summer 2003.

Dutton, J., Dutton, M. and Perry, J. (2002). How do Online Students Differ from Lecture Students?. *JALN*, 6, 1, pp. 1-20.

Felder, M. R. (1993). Reaching the second tier—Learning and Teaching Styles in College Science Teaching. *Journal of College Science Teaching*, 23, 286-290.

Hall, R. J., Pilant, M. S. and Strader, R. A. (1999). The Impact of Web-Based Instruction on Performance in an Applied Statistics Course. *International Conference on Mathematics/Science Education and Technology*, San Antonio, TX.

Hill, J. R. (1997). Distance Learning Environments Via World Wide Web. *In B.H. Khan (Ed.). Web-based Instruction* (pp. 75-80). Englewood Cliffs, NJ: Educational Technology Publications.

Howard, A. H., Carver, A. C,. and Lane, D. W. (1996). Felder's Learning Styles, Bloom's Taxonomy, and the Kolb Learning Cycle: Tying it all together. *In the CS2 Course.* SIGSE, Philadelphia.

Lhyle, K. C. and Kulhavy, R. W. (1987). Feedback Processing and Error Correction. *Journal of Educational Psychology*, 79, 320-322.

Lockard, J., Abrams, P. D., and Many, W. A. (1994). Microcomputers for the Twenty-first Century Educators. Reading, MA, USA: Addison-Wesley.

Moore, M. G. (1989). Distance Education: A Learner's System. *Lifelong Learning*, 12, 8, 8-11.

O'Regan, K. (2003). Emotion and E-Learning. *JALN*, 7, 3, pp. 78-92.

Parkinson, B. and Hudson, P. (2002). Extending the Learning Experience Using the Web and Knowledge-based Virtual Environment. *Computers & Education*, (38), 95-102.

Picciano, G. A. (2002). Beyond Student Perceptions: Issues of Interaction, Presence and Performance in an Online Course. *JALN*, 6, 1, pp. 21-40.

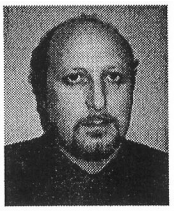
Richardson, C. J. and Swan, K. (2003). Examining Social Presence in Online Courses in Relation to Students' Perceived Learning and Satisfaction. *JALN*, 7, 1, pp. 68-88.

Sunal, W. D., Sunal, S. C., Odell, R. M., and Sundberg, A. C. (2003). Research-Supported Best Practices for Developing Online Learning. *The Journal of Interactive Online Learning*, 2, 1.

Saadé, G. R. (2003). Web-based Educational Information System for Enhanced Learning, (EISEL): Student Assessment, *Journal of Information Technology Education*, 2, 267-277. Available online: http://jite.org/documents/Vol2/v2p267-277-26.pdf

Wegner, S. B., Holloway, K. C. and Garton, E. M. (1999). The Effects of Internet-Based Instruction on Student Learning. *Journal of Asynchronous Learning Networks*, 3, 2.

AUTHOR BIOGRAPHIES



Dr. Raafat Saadé is an assistant professor at the DSMIS department, Concordia University, Canada. He obtained his Ph.D. in Engineering in 1995. He has been the recipient of the Canadian National Research Council postdoctoral fellowship, which he completed at McGill University in Montreal. He has been recognized twice as a North Atlantic Treaty Organization ASI award winner. Mr. Saadé' has over 15 years of industrial experience (engineering, elearning and ehealth), and has worked on over 15 successful projects. During the last 8 years, his work focused on the development and use of intelligent elearning and ehealth applications. Mr. Saadé has published in Information and Management, Journal of Information Technology in Education, Journal of Information Science and Technology and Expert Systems with Applications. Mr. Saadé is also a founder of a non-profit organization (Viéquilibré) targeting the health, educational and spiritual needs of seniors, for a balanced life.

Dr. Dennis Kira is an associate professor at the DSMIS department, Concordia University, Canada. He has been with the Faculty since 1983. He obtained his Ph.D. from University of British Columbia. Dr. Kira teaches System design, decision support systems, data management, data mining, internet related programming, and e-commerce His research activities include E-commerce, web design, distance learning, decision making under uncertainty, neural networks, machine learning, and financial modeling. Dr. Kira has published in IEEE, ORQ and management science among other journals.