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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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Editorial

Decision Sciences

Donald G. Perrin

For the past five years I have been studying and teaching decision sciences for business executives and MBA students. These use linear programming, artificial intelligence, critical-path scheduling, and Excel spreadsheet functions to optimize decisions where many variables are involved. Let me translate this into familiar terms . . .

Linear programming enables you, with the aid of a computer, to optimize a significant number of variables with a single key-stroke. For example:

> Airline booking systems search millions of options to match your ***objective*** – origin and destination – and ***constraints,*** such as number and age of passengers, time and date of travel, quality of service, available seating, meals, cost, and a host of other options. It presents an ***organized list from which you can make your final decision***.
>
> Google searches enormous database resources for simultaneous occurrence of keywords and data you specify. It has algorithms to parse and interpret language and artificial intelligence to place choices most relevant to you at the top of the list of responses.
>
> Geographic Positioning Systems (GPS) enable you to locate any point on the face of the earth and find the shortest or fastest transportation route and locally available services. It will dynamically reroute you in real time to avoid obstacles and optimize performance.

Efficient scheduling is based on critical path methods – the concept that some activities can progress side-by-side until a point where two or more activities must be completed in order to proceed. It is used to schedule industrial processes with fixed time frames (Critical Path Method - CPM) and for military purposes with variable time frames (Program Evaluation and Review Technique - PERT). Think of PERT/CPM like preparing a meal. Which activities must be completed in what order to bring the components together at meal time?

PERT can be used for very large projects:

> Space Travel. On a May 25, 1961, President John F. Kennedy proposed, "landing a man on the Moon and returning him safely to the Earth." by the end of the 1960s. Despite many unknowns about space travel, including (variable) time frames to discover and develop new technologies, the mission was achieved “on schedule” using PERT.

Mathematical functions required for linear programming, PERT, artificial intelligence and robotics can be can be implemented with “Office” computer software containing Excel or a similar program. This means that most computers worldwide are already equipped with software capable of developing and managing these advanced technologies.

In a world where electronic calculators do arithmetic with speed and accuracy, educators teach manual methods and forbid use of calculators. When Google searches can be done on computers and smart phones, we insist on memorization. And in an interactive information rich environment of innovation and exploration, we emphasize learning from lectures and text books. And instead of evaluation using performance testing and portfolios, multiple choice tests are our major testing instruments.

Education can benefit from advanced technologies, starting in early childhood, and building on this foundation throughout primary, secondary and tertiary education. At the same time, we should “weed” the curriculum of content and methods no longer relevant for the 21st century.

Editor's Note: Feedback from statistically large samples of learners provides excellent guidance for instructional design and program improvement. This study shows how detailed, reliable and valid data is used to further develop ICT skills for teacher education in Jordan.

The Degree of Satisfaction Amongst ICTE Graduates at the University of Jordan, Difficulties they Face in Applying Technology to their Teaching Practices and their Suggestions for Developing this Program

Khalid Ajlouni and Atta Abu Al-Haj
Jordan

Abstract

This study aimed at investigating the degree of satisfaction among the higher diploma graduate students of Information and Communication Technology in Education (ICTE) program at the University of Jordan, the difficulties that faced them in handling the program's skills and their suggestions to upgrade it. The population of the study consisted of all students (596 graduates in five batches) of the program, from the summer semester 2007/2008 through the fall semester 2009/2010. The sample of the study consisted of 308 male and female teachers. After analyzing the programs items and reviewing previous studies and theoretical literature, the researchers compiled a questionnaire of their own to gather data. Psychometric parameters such as reliability and validity were calculated. The results revealed that the program's graduates were moderately or even almost very close to highly satisfied with their program. The program's efficiency and its objectives resulted in a high degree of students' satisfaction. Issues of educational environment, facilitation, teaching staff, program's content as well as evaluation got a moderate degree of students' satisfaction. Results showed that graduates faced, to a moderate degree, many obstacles in using information and communication technology skills in their educational practices; the most important of which within the areas mentioned above are: scarcity of time available for teachers to use information and communication technology (ICT) aids in instruction, scarcity of financial and morale incentives given for these teachers, too many students per class, scarcity or even absence of good educational software programs at school, scarcity of computers in school's labs, scarcity of computers connected with the internet, and slow internet connection. Most graduates presented a set of suggestions that aimed at upgrading the program, of which the following are the most important: teaching in detail the Flash educational software instead of the old-fashioned Visual Basic and Authorware techniques, canceling the MS-project- related part of the course project 1 in the preparation stage and providing quality anti-virus programs, as well.

Keywords: satisfaction, diploma, ICTE, difficulties, implementing technology, suggestions, upgrade.

Introduction

The world has witnessed in the last decade of the 20th and the early 21st centuries an incredible progress in information and communication technology, which is accelerating day by day. The world has become a small village, where the time and place barriers, as well as those of culture and politics have really vanished. This progress has led to saving people's time and effort, growing productivity, and upgrading the level of administration, employees and service, as well. Therefore, educational institutions have to benefit from this technology and implement it in their programs, curricula, and activities by learning the skills required in order to attain new methodologies of learning which would serve the learner in his modern life needs as well as his society, so that he can compete in modern information society. (Aba Al-Khail, 2004).

Learning via the tools of information and communication technology aims at making up the deficiency in teaching staff by virtual classes, which would make learning a right for everyone, help in spreading technology in society, and give a wider concept of continuous learning. It, would, also, prepare a generation of teachers and students capable of dealing with technology, modern time skills and successive technological developments, and responding to the requirements of globalization and cognitive economics. It would, moreover, provide alternative assessment and feedback means. Empowered with the new tools, these teachers would be able to participate in upgrading and modernizing curricula, teaching strategies and methodologies and, also, create a rich and varied interactive environment, overwhelmed by dialogue, educational exchange of ideas, through which some courses, which couldn't be taught in the past, can now easily be taught by simulation and modeling. (Altodary, 2004; Al-Salem, 2004).

New and novel innovations arose as a result of this technological progress, such as computers, educational software programs, internet, e-mail, multi-media, interactive video, satellites, local and other nets, both interactive and comprehensive. This led to the appearance of new concepts linked with teaching practices, such as: individualized learning, computer- assisted learning, computer-managed learning, e-learning, e-library, e-schools, e- or virtual universities, digital curriculum, distance learning, video- conferencing, e-books and e- encyclopedias, and others (Al-Ajlouni, 2009).

These innovations are some of the factors that supported the learning-teaching process, and have transformed it from the conventional approach, where the teacher is the sole source of knowledge, and the learner in no more than a receptor of this knowledge, to the stage of interaction, developing skills, renewing knowledge, and forming attitudes within the framework of focusing on the learner himself .This is what the theory of constructivism, which relies on the cognitive approach, believes in. Here, the learner is active and involved in setting up his knowledge, ideas, and imaginations. This cannot be attained unless the learner himself/herself is given enough opportunity for fruitful and open-ended discussion in cooperative groups, where he/she is encouraged to raise new questions about concepts, and thus departs the current experience to a new one. (Abdel-Salam, 2005).The constructionist theory of learning is, therefore, considered a model and a source of modern teaching methods, as well as a source of varied teaching activities. It, moreover, stresses the importance of linking science with technology and society. In fact, when technology is appropriately used, it does provide an important teaching experience, where the learners totally control the learning environment. It could, also, be implemented as an active means for building students' knowledge, boosting their interaction and participation in the learning process, facilitating the access to information sources and improving the whole educational process, as well. (Varasides and Mclsaaco, 2001).

Downes, Andrew, Pam, Ralph, Caroline, Rone, Margret, and Michelle, (2002) outlined four objectives for using information and communication technology, and divided them into four levels (teaching levels) as follows:

The 1st level: encouraging students to acquire information and communication skills as an end in themselves.

The 2nd level: Using information and communication technology to upgrade students' ability within the curriculum.

The 3rd level: Using information and communication technology to enhance students' abilities as a basic requirement within an integrative curricular reform that extends beyond what has actually been learnt.

The 4th level: Using information and communication technology as a basic element in reforms that aim at improving and upgrading the organizational environment of school education itself.

Because of the various uses and benefits of information and communication technology in education, many studies and researches called for the efficient implementation of the technology's means and instruments. Glen's study (Glen, 2001) pointed out that using the computer in teaching was valuable in developing students' learning and achievement , and in giving them a high educational experience .Morales and Roig's study (Morales and Roig, 2002), also, revealed that using information technology in the classroom has led to enhancing students' achievement, creating a positive attitude among them towards the teaching-learning process, and creating a feeling of confidence of their abilities to choose what to learn. The study has, however, revealed that there was not enough time to prepare programs and implement them, and, moreover, there was fear among some teachers, fear of ruining their sovereignty and losing their jobs.

According to Armenakis, Harris and Field (Armenakis, Harris and Field, 1999), there are three stages that allow teachers to go on in using information and communication technology. They are:

1. **Stage of preparation**: It is the stage of understanding and perception, comparing between ideas, and the desire to use.
2. **Stage of experimentation**: It is the stage of changing behavior and shaping it in a new way, just as an experiment.
3. **Stage of institutionalization** : This is a high degree in using technology and a fast change in system.

To guarantee the introduction of information and communication technology effectively in education, there has to be an infra structure in schools, and teachers who know how to use these skills and have positive attitudes towards the technology's role in the educational process and in upgrading these teachers professionally. This is what would make offering in-service training programs in this technology something urgent and vital. Although teachers' pre-service training programs might be good and accurate; however, they are not enough for giving the teacher the capability and competence, particularly in technology, which is everyday changing and always pregnant with something new. Therefore, teachers' training is a must and should be continuous as long as the teacher is alive lest the gap between he and his students gets wider; otherwise, all attempts of reform and development in education would certainly collapse. (Aayasrh, 2005)

In order to realize its objectives, teacher in-service training has to respond to teacher training needs according to their priorities. It, also, has to be organized according to what is novel and new in the field of education (Al-Ashkhari, 2006), and has to be student-centered, as well. Furthermore, Information and communication technology (ICT) shouldn't be used simply as projectors or e-Blackboard learning devices; it, rather, has to be used as an integrative part and accompanied by training, in addition to being means for communication, access , participation and expression (UNESCO, 2003).

In a study conducted by Canning (Canning, 2000), the researcher outlined the capabilities that e-teacher should possess. These include: e-learning course design, e-learning objectives, e-learning content, e-learning strategies, e-learning procedures, e-learning evaluation, e-learning working hours, means of dealing with e-learning problems that may arise while teaching e-learning classes, language system, e-learning expectations, emotional factors, and general information on topics that should be addressed, as well.

The government of Jordan, represented by the Ministry of Education, believes that the teacher is the effective and active tool in pushing the educational process towards success, and in upgrading and renovating it continuously. This, it trusts, can be done within an integrated educational reform which requires a number of modern technical tools that have to be used in education. In order to train teachers to use these technical skills and let them acquire the e-learning capabilities, the Ministry of Education has done painstaking efforts in this context. It has offered some training programs, such as the International Computer Driving License ICDL in 2001 which was intended to train teachers how to use the computer and teaching software programs (Ministry of Education, 2002); Intel Teach to the Future in 2003 which aimed at helping both teachers and students learn well knowledge and skills through using new tools like lesson programming software and consulting e-resources (Ministry of Education, 2004) and Word Links program in2004 which sought to train teachers computer programs (Ministry of Education, 2005). Teachers' success in these programs was a precondition for their job promotion. Furthermore, a number of teachers were enrolled by the Ministry at Yarmouk University by the beginning of 2005/2006 in Information and Communication Technology diploma program which was executed with the help of Inholland and Deleft Dutch universities. This program aimed at qualifying teachers to be able to use Information and Communication Technology inside the classroom, link it with modern teaching methods and develop their capabilities so that they can address students using modern means. It consisted of 6 courses (27 credit hours) distributed over 3 semesters that lasted for a whole academic year. Lectures, both in-class and out-door, in this program were given in most cities in Jordan.(Al-Kader Al-Arabi, 2006).

Another batch of teachers was enrolled in Information and Communication Technology in Education (ICTE) high diploma program at the University of Jordan by the beginning of the academic year 2006/2007. This program arose due to the Ministry's increasing need for training in-service teachers, especially in the field of Information and Communication Technology, and due to the rising need of development and modernization in the Arab World, in general. Scientific and academic cooperation agreements in the domain of technology which were signed between The University of Jordan, Al-Faisal International Saudi Academy and the University of Ohio also led to the rise of this program. The implementation of the program started from King Abdulla 2nd College for Information Technology at the University of Jordan, and under its supervision, and extended by the beginning of the academic year 2007/2008 to reach The University of Al Al-Bait in the north of the Kingdom, Al-Hashemia University and Al-Balqa' Applied University in the middle and Mu'ta University in the south. By the beginning of the academic year 2009/2010, the program was executed in Al-Hussein Ibn Talal University in Ma'an in the south, and Princess Alia and Ajloun Colleges, which are subsidiaries of Al-Balqa Applied University. By the end of the summer term 2008/2009 some 823 teachers (males and females) had graduated , all of them practiced teaching , according to a statistics released by the Post Graduate Study Program at the University of Jordan (University of Jordan, 2009).

This program aimed at enriching participants with many skills: cognitive, mental, analytical and practical; skills that are related to the processes of perception and communication and, moreover, all are linked with information and communication technology. They should effectively be applied in the learning-teaching process, and any learning-related content experience has to be secured via these skills. They should, also, be linked with modern teaching methodologies in order to create new learning environments, characterized by stimulating students' curiosity so that they can be more creative and involved in activities, and resources that call for finding solutions to some problems, by means of ICT skills and resorting to evaluating that process and improving it to the better. The program consisted of 12 courses (30 credit hours) distributed over 3 semesters that lasted for a whole academic year. The practical part of the program outweighed its theoretical one, in terms of lectures (Jordan University, 2006).

Although teacher preparation institutions have done great efforts in order to enable their output of Information and Communication see light, and despite people's varying degree of satisfaction with these programs, teachers do face difficulties and barriers in using this technology in their teaching practices. The following are the most prominent ones: scarcity of computer devices in school's labs, deficiency of educational software, shortage of technical support and advice, scarcity of time allocated to using ICT tools in education, slow-internet connection and scarcity of devices connected with the internet. Some teachers, also, are reluctant to change their ways of getting knowledge which they have been used to for a long time (Khasawneh and Khasawneh, 2008).

After reviewing some foreign and Arabic previous literature in education, a number of studies related to the topic of degree of satisfaction to technical training programs in education have been found. Of these are the following:

Al-Hamran and Ajlouni compiled a study (2009) that aimed at investigating the real status of information and communication technology in exploratory schools in Jordan. The study community and sample consisted of all exploratory schools in Jordan, which were (105) schools, (100) of which were inside the capital Amman, and the other (5) were outside it. The results of the study revealed the Ministry of Education's care to supply the basic modern tools and equipment, and furnish a number of software programs used by teachers in the classroom and, moreover, some teachers were given some laptops. The results, also, pointed out that the most curious person about information and communication technology was found to be the computer coordinator. It, has, also disclosed that the biggest obstacle in implementing information and communication technology in education was the over-crowded classrooms (88.2%), poor internet connection (80%0), student's terribly- weak English (88%), and students' inefficient handling of technology's tools (80.4%).

Ababneh, Sheikh, Abdel-Hamid, Abu Lebda, Qudah and Hamid (2007) from the National Center for Developing Human Resources, conducted an evaluative study for the Information and Communication Technology education diploma program (KADER) at Yarmouk University aimed at providing evidence on the effectiveness of this program The study sample consisted of (58) KADER teachers, (58) counterparts, (58) school principals and (174) teachers that graduated in the academic year 2005/2006. Several methods were used in collecting data. The study has found out the following results:

There were some statistically-considerable differences between Kader teachers and their counterparts (for the benefit of Kader teachers) regarding: self-effectiveness, use of ICT tools and equipment in education, interaction level between teachers and students, use of project-dependent education and use of modern assessment means, as swell.

Leem and Lim's study (Leem and Lim, 2007) tackled the real status of e-learning in Korea and the strategies for boosting competences with the aim of developing graduates' performance skills in e-learning. The study sample included (201) state and private universities. An opinion-poll-based questionnaire was prepared for this purpose. The results showed that both students and teachers suffered from lack of support in this domain and, also, lack of enough opportunities that would help in active enrollment in e- learning courses and programs, especially at some small private colleges and universities. However, at universities that were looked at as big, there was some assistance at these institutions and they had strategies to support, but that was little, and did not count. The two researchers suggested laying out some strategies for assistance depending on the university size (whether big, intermediate or small), upgrading quality control systems in e-learning , reinforcing assistance systems especially regarding faculty members and students and bolstering international cooperation in the field of e-learning, as well.

Al-Tarawneh conducted a study (2006) which meant to know the degree of satisfaction among mathematics teachers in the south territory of Jordan with Intel Teach to the Future program. The

study sample consisted of (300) teachers who have successfully passed this program at the directorates of education in the south of the Kingdom. The study tool which consisted of a.62-item questionnaire was implemented. The items were distributed over six areas, as follows: Intel program's training objectives, program's components, suitability of the training program for trainees, things to train, administrative and training facilitation, and the trainer himself. The study revealed that the teachers were highly satisfied with Intel's program. It has, also, shown that no statistically-considerable difference in teacher satisfaction was attributed to the variables of (gender, experience or classes taught by teacher). The results have, however, disclosed some statistically- considerable differences in mathematics teachers satisfaction that can be attributed to (educational qualification) and that was for the favor of those teachers who have got the High Diploma (Al-Tarawneh, 2006).

Kozma's study (Kozma, 2004) sought to evaluate the effectiveness of: Word Links program in both developed and developing countries, their use of computers to prepare the way for their students for Cognitive Economics, and the level of services offered by the program in these countries. This evaluative study lasted for (3) years, from 1998 through 2000. The evaluation relied on opinions and views of teachers, students, educational supervisors and regional coordinators, as well as on assessment of student learning. The study results showed that the program offered the software and tools that assisted learners to learn better, supplied the internet connection that enabled those learners acquire many computer skills necessary for linking them with other schools or countries through joint projects. However, a number of obstacles that made implementing the computer- related class training difficult were outlined. Of which are: lack of software programs, lack of internet cables in schools, and scarcity of computer labs, as well.

Al-Muezzin conducted a study (2004) that aimed at evaluating the effectiveness of training programs for secondary school teachers in the UAE intended to train them how to use computers, from the perspective of teachers. The study sample consisted of (312) teachers inside and outside the city of Al-'Ain. The researcher prepared a 48-item questionnaire for the purposes of this study. The study found out the following results: The teachers were highly satisfied with the training programs set up to train them how to use the computer; they used computers in teaching, and were aware of its significance and important role in the educational process. The study also found out a statistically- significant difference regarding the degree of satisfaction of teachers with computer training programs. This difference was attributed to gender variable, and in favor of males. However, there was no statistically-significant difference concerning the extent to which the computers were used in teaching that could be attributed to gender. Nor was there any statistically-significant difference concerning the degree of teacher satisfaction with these training programs or how much teachers used computers in teaching that could be attributed to any of the following: experience (1 to 5.6 years and over) , the nature of study subject (scientific, humanitarian) or educational district (inside, outside the city) (Al-Muezzin, 2004).

Annison cconducted a study (Annison, 2002) that aimed at evaluating the High Diploma distance training program in ICT in Education for teachers who have already taken the program from the University of Plymouth, U.K .The program's materials were basically centered on how to integrate the applications of (ICT) with the teaching-learning process. The study sample consisted of (155) teachers chosen deliberately from schools in the south-west of Britain and, also, from outside the U.K. All participated in the program. The results of the study revealed that the training program's curriculum had met all the training and educational needs of teachers, and made teachers understand all of the program's technical and instructional skills. The study, also, concluded that the applications of ICT tools in education were in favor of scientific, rather than humanitarian, materials.

Martin, McMillan, Gersick and Nudell completed a study that intended to evaluate Intel's Program which aimed at integrating technology with education. Emphasis was laid on a group of objectives related to desired effect scale to be obtained through the application of Intel Teach to the Future. A mixture of surveys and case studies has been used in this evaluation to investigate carefully the program's impact

on several levels of school districts participating: grade, school, and the region. The results disclosed that the conditions that were already present in the classroom, school level, as well as the region, all have played an important role in determining whether teachers have transformed the lessons learned in their training into their actual teaching, and that teachers developed their experience of training into tangible changes when they have learnt enough technical skills in their classrooms, and had confidence that their school's administration and that of its region support experimentation and innovation in the classroom (Martin, McMillan, Gersick and Nudell, 2002).

Study's Problem and Questions

We are living in the age of Information and Communication Technology and there is a bad need to incorporate this technology in all learning stages. Therefore, the University of Jordan (UJ) couldn't live away from these developments in the educational-learning system. It quickly stepped into design and offered a whole academic program based on this technology. It intends to teach teachers the skills of this technology, and to invest in this technology to upgrade learning and education. The Ministry of Education spent lots of money to achieve that objective, and it is eager to get additional numbers of teachers enrolled in the program. Being directly involved in the academic educational environment, the two researchers noticed varying viewpoints about the program and noted difficulties that faced teachers in implementing the ICT-related skills in their schools. Furthermore, so far as the researchers can determine, no studies about the program have so far been conducted and a considerable period of time has elapsed since the introduction of the program. Consequently, this study was initiated to investigate the degree of satisfaction of graduates with the program, and the difficulties they experienced in applying the ICT-related skills in their educational practice. Thus, the study attempts to answer the following questions:

1. What is the degree of satisfaction of graduates with the program?
2. What are the difficulties that faced graduates in the application of ICT-related skills in their educational practices?
3. What are the most important suggestions needed to develop the ICT program from the point-of-view of graduates?

Study Objectives

This is a concluding evaluative study and is categorized as a study for evaluating the output. It attempts to reveal: the degree of graduates' satisfaction with the program, the obstacles and difficulties that faced them in implementing the ICT- related skills in their teaching practices and, also, it presents some of graduates' suggestions to upgrade the program and enable the people in charge of it specify the program's areas that need modernizing and development.

Study Importance

The importance of the study lies in the following points:

1. It discloses the graduates' degree of satisfaction with the program, and, thus makes up for the lack of educational literature related to acquired capabilities in technical training programs. It, also, shows the degree to which these objectives can be realized.
2. It specifies the nature of difficulties that hinder the implementation of educational technical skills (that have been learnt in the training programs) in real educational practice.
3. It aids in listing the e-teacher competences in all different scholastic stages.
4. It exclusively studies a wide range of the Kingdom's teachers in all three regions: The north, middle and south, which would make the results of the study more general.

5. It, also, offers some information and new ideas about the reality of the program, which would help in improving and upgrading it.

Operational Definitions of the Study Terms

Degree of Satisfaction: It is the estimate or rating the graduate assigns for himself on questionnaire items (prepared for this purpose) that measure his satisfaction with the program in all of its six fields: Program's objectives, program's effectiveness, program's content, program's teaching staff, program's teaching environment and facilitation, and evaluation in the program.

Graduates: All teachers, males and females, which have graduated from the program starting from the summer semester 2007/2008 through the 1st of 2009/2010.

The Program: It is one of UJ's study programs that follow the B.A. degree. It lasts for three semesters (30 credit hours) and its graduates are given upon finishing their study the High Diploma certificate in Information and Communication Technology I.C.T.

Information and Communication Technology: It is an integrated system that includes acquiring, storing and processing of information by integrating computers with visual communication systems which include educational software, compact discs (CDs), multi media, internet, e-mail, interactive video and other innovations in technology.

Obstacles and Difficulties: It is the estimate or rating the graduate assigns to himself on the questionnaire's items (which were prepared for this purpose) for the difficulties that faced him in implementing the ICT-related skills in his teaching practices in all five areas, which are related to: school's conditions, educational software, teachers, students and the internet, as well.

Limitations and Delimitations of the Study

1. Only **High Diploma** graduates of Information and Communication Technology in Education (ICTE) at the University of Jordan U.J. were subjected to this study. It included all the program's graduates from the beginning of the summer semester 2007/2008 through the 1st semester of 2000/2010. They were (308) teachers.
2. After reviewing previous theoretical literature and research in ICTE , and having outlined the program's technological skills and analyzed it's items, the two researchers implemented a questionnaire's whose reliability and validity have first been checked.

Methodology of Study and Procedures

The study followed the descriptive approach. This approach suited the nature of the study and dealt with it as it was in reality. Data were collected from the field, categorized, analyzed, and then conclusions were drawn.

Study Sample and Community

The study community consisted of all **ICTE** High Diploma graduates who have studied at the U.J. and other institutes where the program was taught. As previously mentioned, they were (596) male and female teachers distributed into 5 patches, from the summer semester of 2007/2008 through the 1st of 2009/2010. .

Whereas the study's sample included just (308) teachers, of whom 120 were males and 188 were females. This represents 54.41% of the all questionnaires sent to the (566) graduates via the e-mail, or handed to them in schools where they taught. 323 questionnaires returned filled satisfactorily, while (15) were excluded because they were either unfilled or filled

unsatisfactorily. Table (1) shows the number of questionnaires distributed, returned, excluded and those valid, and the corresponding percentages according to gender.

Table 1
Number of Questionnaires Distributed, Returned, Excluded and Valid According to the Gender Variable

Gender	No of questionnaires distributed	No of questionnaires returned	No of questionnaires excluded	No of questionnaires valid	Percentage
Males	204	128	8	120	58.82
Females	362	195	7	188	51.93
Total	566	323	15	308	54.41

Study Tool

This study aimed at investigating the degree of satisfaction with the program among graduates and the difficulties and obstacles that faced them in implementing the (ICTE) skills in their actual teaching. To achieve this goal, the two researchers prepared the tool of the study, which is a questionnaire based on analyzing the program's content, on the researchers personal experience and on related previous studies and theoretical research, as well as on some questionnaires used in the following studies (Shammout, 2008; Al-Metairy, 2007; Al-Ashkhari, 2006; Al-Tarawneh, 2006; Al-Ajlouni, 2004; Al-Muezzin, 2004; Madden, et al., 2005; Duvel and Pate, 2004; Beggs and Murphy, 2003; Wilson, et al., 2003).

The study tool consisted of four parts starting with a covering letter, as follows:

1. Part One: It contains general demographic data about the graduate (the teacher). This includes: (gender, practical experience, school where he/she teaches, school location, school gender, school level, subjects taught by him/her, ICT courses he/she has taken) .
2. Part Two: It talks about the degree of satisfaction of graduates with the program. It includes (43) items distributed over 6 domains, as follows:

    1st domain: This consists of (5) items intended to measure the ICTE program's **objectives**. It includes items (1 – 5).

    2nd domain: This consists of (11) items intended to measure the ICTE program's **effectiveness**. It includes items (6 – 16).

    3rs domain: This includes (11) items intended to measure the ICTE program's **contents**. It includes items (17 – 25).

    4th domain: This consists of (7) items intended to measure the ICTE program's **teaching staff**. It includes items (26 – 32).

    5th domain: This consists of (6) items intended to measure the ICTE program's **facilitation and teaching environment.** It includes items (33 – 38).

    6th domain: This consists of (5) items intended to measure the ICTE program's **evaluation**. It includes items (39 – 43).

    The researchers used Likert's four-point scale for estimating the degree of satisfaction as follows: (Strongly agree, Agree, Disagree, Strongly disagree) and these responses were

given the numbers (4, 3, 2, 1), respectively. The researchers assigned the following categories for expressing the degree of satisfaction:

- For mean values from (1.00-2.00), i.e., comparative importance from (25-50), this refers to (high degree of satisfaction).
- For mean values from (2.01–3.00), i.e., comparative importance from (50.01–75) this refers to (medium or moderate degree of satisfaction).
- For mean values from (3.01–4.00) i.e., with comparative importance from (75.01-100) this refers to (low degree of satisfaction).

3. **Part Three:** It tackles the obstacles and difficulties that faced graduates in implementing the (ICTE) related skills in their classroom practices. It consists of (27) items distributed over (5) domains, as follows:

   1st domain: It consists of (7) items, i.e. items (1-7), intended to measure the difficulties related to school's environment

   2nd domain: It consists of (4) items, i.e., items (8-11), intended to measure the software-related difficulties.

   3rd domain: It consists of (5) items, i.e., items (12-16), intended to measure the teacher-related difficulties.

   4th domain: It consists of (5) items i.e., items (17-21), intended to measure student-related difficulties.

   5th domain: It consists of (6) items, i.e., items (22-27), designed to measure the internet-related obstacles.

   - In this part, the researchers have assigned for each item a rating on Likert's five-point scale, as follows: (to a great degree, to a big degree, to an intermediate degree, to a little degree, to a very little degree) and these responses were given the numbers (5,4,3,2,1), respectively.
   - The following categories were adopted to indicate the degree of difficulty that faced graduates in implementing the ICTE skills in their actual teaching: For means from (1 -2.33) and Relative Importance (RI) of (0.0% –46.6%) indicated a low degree of difficulty; For means from (2.34 – 3.66) and RI of (46.7% –73.2%) indicated a moderate degree of difficulty; and For means from (3.67–5.00) and RI of (73.3% – 100%) indicated a high degree of difficulty.

4. Part Four: It is comprised of an open question about the most prominent suggestions to upgrade the (ICTE) program. The most frequently mentioned suggestions appear first.

Validity of the Study

To verify the questionnaire's validity, the questionnaire was reviewed by some referees from the faculty members at the University of Jordan : (20) referees from King Abdulla 2nd School for Information Technology, and also other ones of different specialties at the College of Educational Sciences , like Educational Technology, Psychometric Measurement and Evaluation. It was, also, reviewed by the director of Technological Projects at the Ministry of Education. They were all asked to judge the items of the questionnaire in terms of their importance, clarity and relevance, and to introduce any necessary modifications for the sake of achieving the study's goal.

The researchers have benefited from the referees notes. Each item that has been accepted by 80% of the referees was adopted, and those items which got lower than 80% of the consent of referees were modified or even deleted. Thus, the number of accepted items was (70).

Reliability of the Study

To test the questionnaire's reliability, the researcher followed the test-retest Reliability method. The questionnaire was applied to an exploratory sample that consisted of (30) teachers (15 males and 15 females) chosen randomly from the original study community, before they were given the questionnaires. (21) days separated test and the retest sessions. Pearson's correlation coefficient for the overall degree of satisfaction of graduates with the program part was found to be (0.95), whereas it was (0.94) for the difficulties that faced graduates in implementing ICTE related skills in their actual teaching. These values were high enough to be adopted for the study's objectives.

To find out the value of the questionnaire's internal consistency, the researchers used the Cronbach-alpha equation. The internal consistency values for the degree of satisfaction of graduates with the program were (0.91), while it was (0.93) for the part of difficulties that faced them in implementing the ICTE related skills in actual teaching. These values are considered high enough for the purposes of this study. Table (2) down shows Pearson's coefficient values for the test- retest according to Cronbach's alpha equation for internal consistency for the domains of the two parts.

Table 2
Results of test-retest reliability coefficients (according to Pearson) and internal consistency coefficients (according to Cronbach alpha)

Degree of Satisfaction ***Domains***	**No of items**	**Reliability coefficient (Pearson)**	**Internal Consistency coefficient (Cronbach alpha)**
1st domain: ICTE program objectives	5	0.88	0.80
2nd domain: ICTE program effectiveness	11	0.84	0.85
3rd domain: ICTE program content	9	0.93	0.68
4th domain: ICTE program teaching staff	7	0.95	0.68
5th domain: ICTE program facility and teaching environment	6	0.91	0.80
6th domain: ICTE program assessment	5	0.90	0.85
Total Degree of satisfaction	**43**	**0.95**	**0.91**
Domain of Difficulties			
1st domain: school-related difficulties	7	0.94	0.87
2nd domain: educational software-related difficulties	4	0.91	0.87
3rd domain: teacher-related difficulties	5	0.80	0.63
4th domain: student-related difficulties	5	0.92	0.85
5th domain: internet-related difficulties	6	0.89	0.80
Whole degree	**27**	**0.94**	**0.93**

Results of the Study and a thorough Discussion :

I. Question One- Related Results

What is the degree of satisfaction of graduates with the program?

In order to answer this question, the researchers calculated the mean, standard deviation, relative importance, order and degree for all items talking about the different domains of. Graduates' degree of satisfaction, as Table 3 below shows.

Table 3

Mean, Standard Deviation, Relative Importance (RI), Order and degree of items that talk about the different domains of Degree of Graduate Satisfaction with the Program

No	Items	Mean average	Standard Deviation	Relative Importance	Order	Degree
1. Graduate Satisfaction with the Program Objectives *Domain*						
1.	Consistent with the philosophy of education and educational development projects in Jordan	3.19	0.61	79.8	2	high
2.	Clear and explicit for teachers	3.06	0.68	76.5	4	high
3.	Emphasizes the changing role of the teacher in the teaching-learning process	3.26	0.58	81.5	1	high
4.	Meets teachers needs and enhances their professional capabilities	3.13	0.61	78.3	3	high
5.	Applicable in the field of education	2.95	0.69	73.8	5	intermediate
Whole Domain		**3.12**	**4.17**	**78.00**	**2**	**high**
2. Graduate Satisfaction Degree with the Program Effectiveness *Domain*						
6.	Gave me the ability to organize and plan well					
7.	Helped me in implementing new strategies needed for curriculum application	3.19	0.63	79.8	5	high
8.	Upgraded my technological competence in education and enabled me implement that in teaching	3.25	0.58	83.8	2	high
9.	Improved my ability in training students in problem-solving- based learning	3.00	0.67	75.0	10	intermediate
10.	Gave me the ability to analyze curricula and enrich them by learning-teaching activities	3.11	0.69	77.8	7	high
11.	Provided me with measurement and educational evaluation-based principles and their application in teaching	3.38	0.68	84.5	1	high
12.	Taught me the abilities of developing students creative and critical thinking	2.92	0.84	73.0	11	intermediate
13.	Enabled me to produce suitable learning software programs for students	3.21	0.59	80.3	4	high
14.	Taught me how to evaluate and select the educational software and websites	3.25	0.62	81.3	3	high
15.	Enabled me design the teacher webpage and publish it on the internet	3.06	0.64	76.5	9	high
16.	Taught me the ability to use modern evaluation means ,like noticing, achievement bag and setting up Exam Online	3.07	0.60	76.8	8	high
Whole Domain		**3.16**	**0.41**	**79.00**	**1**	**high**
3. Graduate degree of Satisfaction with the Program's Content *Domain*						
17.	Designed according to the trend of competencies necessary for teachers	3.06	0.64	76.5	9	high
18.	Agrees with the program objectives	2.94	0.54	73.5	5	intermediate
19	Agrees with what has been mentioned in teaching materials plan	3.06	1.82	76.5	1	high
20	Courses included various integrated subjects.	2.93	0.63	73.3	6	intermediate
21	Study units are inter-related and presented	2.68	0.72	67	9	intermediate
22	Study materials achieved a balance between theory and practice.	2.71	0.72	67.8	7	intermediate
23	Academic accuracy and modernity are there, and	2.96	0.62	74.0	4	intermediate

	it keeps up with modern educational and scientific trends					
24	Suitable for the scheduled lectures.	2.71	0.72	67.8	7	intermediate
25	Content of some study materials are repeated in some other ones.	3.00	0.73	75.0	3	intermediate
4. Graduate degree of satisfaction with the teaching staff of the program *Domain*						
26	Aroused teacher motivation for more learning.	3.06	1.84	76.5	2	intermediate
27	Executed lectures in an orderly and organized manner.	2.86	0.71	71.5	6	intermediate
28	Used varied means for the different levels of knowledge.	2.76	0.79	69.0	7	intermediate
29	Adapted activities so they could suit content and objectives.	2.87	0.63	71.8	5	intermediate
30	Encouraged teachers to undertake individual or group projects.	3.19	0.62	79.8	1	high
31	Offered advice and practical training applicable in the field of education	2.90	0.66	72.5	3	intermediate
32	Accepted teacher opinions and ideas and invested their notes for the sake of achieving the objectives of the program.	2.88	0.79	72.0	4	intermediate
Whole Domain		**2.93**	**0.55**	**73.25**	**4**	intermediate
5. Graduate degree of satisfaction with the teaching environment and facilitation in the program *Domain*						
33	Efficient computers are there in labs.	`3.27	0.72	81.8	2	High
34	Maintenance is available for computers and accessories.	3.00	0.74	75.0	5	intermediate
35	Basic educational software is available.	3.03	0.73	75.8	4	High
36	Easy access and use of the Internet.	3.28	0.74	82.0	1	High
37	Good anti-virus programs installed.	2.22	0.977	55.5	6	intermediate
38	Facilities such as libraries, labs, and teaching halls are available to help in implementing the necessary teaching and learning activities.	3.15	0.75	78.8	3	high
Whole Domain		**2.99**	**0.56**	**74.75**	**3**	Intermediate
6**. Domain of graduate satisfaction with evaluation in the program**						
39	The program included different evaluative methods at different stages.	2.96	0.63	74.0	1	intermediate
40	The teaching materials included evaluative ways designed to arouse and develop teachers' thinking.	2.66	0.66	66.5	2	intermediate
41	When evaluating teachers, standards to achieve objectivity were followed.	2.53	0.78	63.0	5	intermediate
42	Instruments used to evaluate teachers were appropriate and sufficient	2.64	0.75	66.0	3	intermediate
43	Different forms of feedback were given to teachers which would help in upgrading and improving their performance	2.58	0.74	64.5	4	intermediate
	Whole domain	2.68	0.56	67.0	6	intermediate
	All domains	2.98	0.35	74.5		intermediate

As table (3) above shows, the degree of satisfaction of graduates with the program was generally intermediate, with a mean of (2.98) and Relative Importance (RI) of (74.50%). Following is a detailed discussion of each of the graduate degree of satisfaction domains.

1. *Domain One*- related results: Program Objectives

With a mean average of (3.12), relative importance RI of (78.0%) and a high degree of satisfaction, this domain was ranked the second. Four out of its five items got a high degree. Item 3, which emphasizes the changing role of the teacher in the learning- teaching process, has got the highest mean (3.26) and relative importance (81.5%) , followed by item (1) " agrees with the philosophy of education and educational development projects in Jordan' . This item,1, has got a mean of (3.19) and relative importance of (79.8%), followed by items (2) and (4) which had

relative importance of (78.3%) and (76%), respectively. The researchers attributed this to the fact that the program has met the Ministry of Education's philosophy, plans, recommendations of conferences, national initiatives and international projects that aimed at implementing technology in education, preparing the technological teacher and changing his role to carry out cognitive economics-based curricula which rely on technology. Therefore, the objectives of teacher-enrolment in the program were clear. These objectives do not represent just a goal but also they seek to upgrade and develop the teacher's knowledge and professional skills. Item (5) "applicable in the field of education "has, however, got the least mean (2.95) , relative importance (73.8%) and intermediate degree of satisfaction. This points out that the results are reasonable because of the lack of technical support given to schools. It might also be due to the fact that some teachers resist change. They fear that technology might replace them at schools or increase their responsibilities in the absence of a rewarding return for them for using technology.

2. *Domain* Two-Related Results: Program Effectiveness

With a mean average of (3.16), relative importance of (79.0%) and a high degree of satisfaction, this domain was ranked the first. (Nine) out of its (eleven) items got the same high degree of satisfaction. Item (11) "taught me psychometric measurement and evaluation-related principles that can be used in teaching "got the highest mean of (3.38) and relative importance of (84.5%) followed by item (8) "upgraded my technological competence and enabled me to implement that in teaching "got mean of (3.35) and relative importance (83.8%), followed by items (14.13.7.6.10.16.15) with relative importance of (31.3%),(80.3%),(79.8%),(78.8%),(77.8%), (76.8%), (76.5%), respectively. The researchers attributed that to the fact that the program had really taught teachers and instilled in them these skills and developed them well. This is because of the nature of the well - chosen study materials which were assigned to teachers and which met their needs and the teaching requirements, in order to keep up with the incredible development in education, especially in ICTE and which would serve the learning- teaching process. Moreover, teachers are quite aware of the significance of knowledge and the value of these skills, which motivated and encouraged them to learn them, and consequently charged them with a high degree of satisfaction. Item (12)" Taught me the abilities of developing student creative and critical thinking', however, got the lowest mean (2.92) and lowest RI (73.0) in this domain, followed by item(9) " Improved my ability in training students in problem-solving based learning" which got a mean of (3.00) and a RI of(75.00%)and a moderate degree of satisfaction for both items.. This might be due to inability on the part of teachers to implement these skills well in teaching. They are considered advanced skills and need special teaching strategies and more efficient teachers. There are now special software programs used in developing these skills, but, unfortunately, they are not available in the program.

3. Domain Three- Related Results: Program Content

With a mean of (2.89), RI of (72.25%) and moderate degree of satisfaction, this domain was ranked the fifth. Of the domain's 9 items, both items (17) "Designed according to the trend of competencies necessary for teachers" and item (19) "Agrees with what has been mentioned in teaching materials plan "got the highest mean (3.06)and highest RI (76.5%) and , also, a high degree of satisfaction. This might be due to the deliberate care the program designers have given to study materials, i.e. they divided these materials into special units, each contained all skills, activities, drills and applications necessary to achieve the objectives of the whole program.(7) items, on the other hand, got just a moderate degree of satisfaction, the least of which in both mean and RI was item (21)" Study units are inter-related and presented in a logical and serial manner" which had a mean of (2.68) and a RI of (67.0%). Item (22)" Study materials achieved a balance between theory and practice", and item (24)" Suitable for the scheduled lectures "got a mean of (2.71) and a RI of (67.8%) for each, respectively. For items (20, 18, 23, 20) values of RI ranged from (73.3% - 75.0%). This might be due to limited time through which the program had

to be executed, which meant that teachers had to strictly stick to study units according to the time allocated for each in the preset plan. Moreover, teachers were unable to devote any extra time for subjects the teachers believed they were not fully taught, or there was a discrepancy between theory and practice in teaching them.

4. Domain Four - Related Results: Teaching Staff in the Program

With a mean of (2.93), RI of (73.25%) and moderate degree of satisfaction, this domain was ranked the fourth. Two of its 7 items got a high degree of satisfaction. They are item (30)" Encouraged teaches to undertake individual or group projects**"**, and item (26)" Aroused teacher motivation for more learning**"**. The former got a mean of (3.19) and a RI of (79.8%), while the latter's mean and RI were (3.06) and (76.5%), respectively. This is attributed to the faculty members' ability to rouse motivation among teachers**.** Furthermore, the teachers exchanged their experiences with each other and cooperated in individual or group projects. This stemmed out from their deep conception of the importance of team work and exchanging experience. Five items, on the other hand, got a moderate degree of satisfaction, the least of which in both mean and RI was item (28)" Used varied means for the different levels of knowledge**"** which got a mean of (2.76) and a RI of (69.0%), followed by item (27) " Executed lectures in an orderly and organized manner**"** which got a mean of (2.86) and a RI of (71.5%). For items (29, 32 31) RI values ranged between (71.8% - 72.5%). This might be due to the lack of direct communication with teachers and due to not knowing well teachers needs regarding merging technology with education. Moreover, there was no focal point that merges all subjects, from which activities and tasks stem, and most faculty members, though know very well what information technology means, however, they might not have the enough knowledge of teaching strategies or the various facets of education.

5. Domain Five-Related Results: Teaching Environment and Facilitations in the Program

With a mean average of (2.99), RI of (74.75%) and an intermediate level of satisfaction, this domain has ranked 3rd. Four of its six items got a high degree of satisfaction , the highest of which in both mean and relative importance was item (36)"provides suitable and easy access to the internet because of the good infrastructure of the university ".It got a mean of (3.28), RI of (82.0%) , followed by item(33)"Provide efficient computers in labs" which got a mean of (3.27) and RI of (8108%) followed by items (38) and (35) which got RI (78.8%) and (75.8%), respectively. The researchers attributed this to the University's care to carry out the program and eliminate any obstacles and barriers that might hinder its path, by securing a sufficient number of modern computers and their labs, connecting them with the internet, providing modern educational software, and, also, providing other facilities, such as libraries, teaching halls, with good and comfortable furniture and AC appliances. All of that helped largely in reaching that high degree of satisfaction. Item (37):" secures good anti-virus programs", on the other hand, got the lowest mean of (2.22) and RI of (55.5%), followed by item (34):"provides necessary maintenance for the computers and their accessories." That could be accounted for, the researchers say, to leaving the computers and the other hardware, for a long time, without any maintenance, and, moreover, to the absence of good anti-virus programs loaded on those computers, which would hinder their progress and harm their PC discs. This is what the graduates had pointed out to, as obstacles that faced them at a percentage of (77.3%) in the 1st item, and (78.9%) in the 2nd item,

6. Domain Six-related results:

This domain got the lowest rank: a mean of (2.68), RI of (67.00%) and an intermediate degree of satisfaction for all its (5) items. The highest one in terms of mean and RI was item (39)"The program included different evaluative methods used at different stages". It got a mean of (2.96) and RI of (74.00%). Item (41):"Objectivity-realizing criteria among teachers were followed ", on

the other hand, got the least mean of (2.53) and RI of (63.3%). For the items (43, 42, 40), RI values ranged from (64.5% -66.5%).

According to the researchers, that could be due to many reasons: The evaluation methods followed in the program were not very good, and there is the possibility that some graduates were affected the grades they got in the program courses. They might have mixed these grades with judging the items in this domain.

When the results of this question were compared with results of other related studies, it has been found that they agree with the results of each of :(Al-Ohali, 2003; Martin et al; Annison 2002; Kozma 2004).However, they disagree and diverge from results of :(Al-Tarawneh, 2006; Al-Muezzin, 2004; Al-Younis and Al-Majali, 2004).The 1st study results revealed that teachers of mathematics in the south of Jordan were highly satisfied with (Intel) program, while those results of the 2nd study showed that teachers in the UAE were highly satisfied with the computer training programs. However, the last study results pointed out those Faculty of Educational Sciences students at Mu'ata University expressed their desire to modify the content of the educational computer course to match their studies in a better way.

***II. Question Two-related Results*:**

What are the obstacles that face graduates in implementing the ICTE skills in their actual teaching?

To answer this question, the researchers calculated the mean, standard deviation, relative importance, order, and degree of satisfaction for each of the items that talk about the obstacles which faced graduates in implementing the ICTE skills in their actual teaching and in all domains in general, as table (4) shows.

Table 4

Mean, standard deviation, relative importance, order and degree of satisfaction of items that describe obstacles that face graduates in implementing ICTE skills in their actual teaching

No.	Items	Mean average	Standard deviation	Importance percentage	Order	Degree
	1.Domain of *Difficulties Related to School's Environment*					
1.	Over-crowded classes	3.88	1.32	77.6	1	High
2.	Lack of computers in school labs	3.66	1.22	73.2	2	Intermediate
3.	Computers are old, unreliable or with missing parts	3.08	1.26	61.6	4	Intermediate
4.	Different computer make or specifications	2.65	1.28	53.0	7	Intermediate
5.	Lack of good anti-virus programs	3.21	1.40	64.2	3	Intermediate
6.	Lack of administrative support for ICTE tools in teaching	2.92	1.39	58.4	6	Intermediate
7.	Lack of technical support and advice	2.94	1.40	58.8	5	Intermediate
The domain as a whole		**3.19**	**1.00**	**63.80**	**3**	**Intermediate**

2. Domain of *Difficulties Related to the Educational software*						
8.	Lack of educational software available in school	3.80	1.17	76.0	1	High
9.	Unsuitability of educational software for students' level	3.53	1.18	70.6	4	Intermediate
10.	Lack of educational software that use good standard Arabic	3.66	1.14	73.2	3	Intermediate
11.	Lack of *quality* educational software	3.74	1.17	74.8	2	High
The domain as a whole		**3.68**	**0.99**	**73.6**	**1**	**High**
3. Domain of *Difficulties Related to Teachers*						
12.	Lack of time devoted to teachers to use ICTE tools in teaching or preparing appropriate educational software that suits students level	4.35	0.94	87.0	1	High
13.	Lack of teachers convinced of the benefits of E-learning	2.90	1.33	58.0	4	Intermediate
14.	Lack of financial or moral incentives given to teachers	4.21	1.04	84.2	2	High
15.	Implementing ICTE tools weakens teacher's role in teaching	2.25	1.37	45.0	5	Low
16.	Lack of coordination between teachers of computer and those other subjects	2.97	1.32	59.4	3	Intermediate
4. Domain of *Difficulties Related to Students*						
17.	Poor motivation on the part of students to learn through the ICT tools	2.03	1.26	40.6	5	Low
18.	Lack of experience on the part of students to implement the ICT tools in teaching	2.52	1.31	50.4	4	Intermediate
19.	Students poor English hinders their implementation of ICT tools in teaching	2.84	1.42	56.8	3	Intermediate
20.	Students get sidetracked in other things while using ICT tools	2.87	1.30	57.40	2	Intermediate
21.	Scarcity of computers in students' homes	3.26	1.32	65.2	1	Intermediate
Domain as a whole		**2.70**	**1.04**	**54.00**	**5**	**Intermediate**

5. **Domain of *Difficulties Related to the Internet***						
22.	Scarcity of computers connected with the internet	3.50	1.35	70.0	2	Moderate
23.	Slow internet connection or even frequent disconnection	3.54	1.24	70.8	1	Moderate
24.	The ineffectiveness of Eduwave software	2.79	1.16	55.8	5	Moderate
25.	Lack of censorship on the internet which means easy access to sites inconsistent with our customs and traditions	2.77	1.32	55.4	4	Moderate
26.	Scarcity of appropriate educational sites	3.07	1.18	61.4	4	Moderate
27.	Some websites ask for pre-paid subscription	3.13	1.28	6.2.6	3	Moderate
Domain as a whole		**3.13**	**0.88**	**62.60**	**4**	**Moderate**
All Domains		**3.19**	**0.74**	**63.80**		**Moderate**

As table (4) shows, graduates generally faced difficulties in implementing the ICTE skills in their actual teaching to a moderate degree at a mean of (3.19) and RI of (63.80). Following is a detailed discussion of each of the domains of difficulty.

1. *Domain1-Related Difficulties*: Difficulties related to School's Environment**:**

With a mean of (3.19), RI of (63.80%) and a moderate degree of difficulty, this domain was ranked the 3rd. Out of its 7 items, item1"over-crowded classes" got the highest mean (3.88) and the highest RI (77.6%) and also a high degree of difficulty, followed by item(2) " scarcity of computers in school labs" which got a mean of (3.66), RI of (73.0%) and a moderate degree of difficulty. Item (4) " different computer specifications and makes in the same lab ", however, got the lowest mean of (2.65), RI of (53%), followed by item (6) " lack of administrative support for using ICT tools in teaching " which got a mean of (2.92), RI of (58.4%) and a moderate degree of difficulty for both items. For items (5, 3, 7), RI was (64.2%%, 61.6%, 58.8%), respectively. The researcher attributes this to the gap between the real status of infrastructure in most schools and the requirements of using ITCE tools. These schools need refurbishment and improvement in terms of teaching halls and labs, which should be well-lit and ventilated and, moreover, fitted with ACs and good quality computers that have regularly to be ant-virus programmed and subjected to maintenance. These results agree with those of (Doumairi, 2008; Ababneh et al, 2007; Al-Ashkhari, 2006; Al-Hamran, 2006; Al-Ajlouni, 2004; Martin et. al, 2002; Haris, 2002).

2. *Domain 2-related Results*: Difficulties Related to the Educational Software**:-**

This domain was ranked the 1st. It has got a mean of (3.68), RI of (73.60%) and a high degree of difficulty. Out of the 4 items of this domain, item (8) "scarcity of educational software in schools" got the highest mean (3.80) and RI of (76.0%), followed by item (11) "lack of quality educational software" which got a mean of (3.74) and an RI of (74.8%).This reveals an obvious difficulty encountered in implementing these two items. Item (9) "unsuitability of educational software for students' level" got a mean of (3.53), which is the lowest of the 4 items, and a RI of (70.6%). Item (10) "scarcity of educational software prepared in good Arabic" got a mean of (3.66), RI of (73.2%) and a moderate degree of difficulty encountered in implementing these two items. The researchers attributed this to the fact that the Ministry of Education has already

computerized and programmed most curricula and loaded them on the e-gate Eduwave and teachers, as well as students, can access to these computerized materials. The presence of ready made educational software motivated neither the teachers nor schools to try to design or produce any software. Moreover, the teachers, being burdened by so many scholastic tasks, did not have enough time to produce good quality educational software. The inadequate infrastructure at schools, lack of modern equipment and lack of study material-related software of specific objectives, could also be added to these obstacles. Consequently, teachers had to resort to ready made educational software, which did not meet the scientific criteria, and most of which were prepared in English and, also, expensive. The language barrier as well as the high cost of these software represented a stumbling block that hindered their implementation. These results agree with the results the following studies: (Al-Ajlouni, 2009; Al-Hamran, 2006; Khaza'leh and Jawarneh, 2006; Mobuslat, 2005; Al-Ajlouni, 2004; Kozma, 2004; Harris,2000).

3. *Domain3-Related Difficulties*: Difficulties Related to Teachers**:-**

With a mean of (3.34), RI of ((66.8%) and a moderate degree of difficulty, this domain was ranked the second. Two of its (5) items, namely items (12) and (14), got a high degree of difficulty met in implementing them. Item(12) " Lack of time devoted to teachers to use ICTE tools in teaching or prepare appropriate educational software that suits students level " got the highest mean (4.35) and highest RI (87.0%), followed directly by item (14) "Lack of financial or moral incentives given to teachers "which got a mean of (4.21) and RI of (84.2%), then items (16, 13) which both got a moderate degree of difficulty and a RI of (59.4%, 58.0%), respectively. Item (15) "Implementing ICTE tools weakens teacher's role in teaching", however, got the lowest mean (2.25), lowest RI (45.0%) and a low degree of difficulty met in implementing the program. The researchers attributed this to the big teaching load and the presence of too many educational tasks imposed on teachers, the long time devoted to preparing the E- content as well as to the lack of moral and financial incentives given to teachers. All of that have negatively affected the implementation of ICTE tools in teaching, These findings agree with those of the following studies: (Doumairi, 2008; Abu al-Aish, 2007; Shirawi, 2005; Al-Zahrani, 2005; Goodison, 2001; Harris, 2000).

4*. Domain 4-Related Results:* Difficulties Related to Students:-

With a mean of (2.70), RI of (54.00%) and a moderate degree of difficulty, this domain was ranked the last. Four of its five items got a moderate degree of difficulty, the highest of which in terms of both mean and RI was item (21) "Scarcity of computers in students' homes 'which got a mean of (2.26) and RI of (65.2%), followed by item (20) "Students get sidetracked in other things while using ICT tools " which got a mean of (2.87) and RI of (57.4%), then items (19, 18) which got RI of (56.8%, 50.4%), respectively. Item (17), "Poor motivation on the part of students to learn through the ICT tools", however, got the lowest mean (2.03) and lowest RI (40.6%) and, also, a low degree of difficulty met in implementing the program. This might be attributed to the fact that most Jordanian families have at least one PC at home. The prices of PCs have recently fallen down considerably; therefore, getting a PC is no longer an obstacle. Parents, also, do realize the importance of these devices in facilitating the learning of their sons. Through these appliances they could perform many homework assignments, activities and tasks. Modern curricula encourage the use of ICTE tools, which would lead to enriching students' knowledge, developing their mental and practical abilities and complementing what goes inside the classroom. The issue of getting sidetracked in other things while using ICT tools depends on how the teacher applies these tools in the classroom. Now these findings concur with those of the following studies: (Al-Hamran, 2006; Chen, 2000; Leem and Lim, 2007).

5. Domain 5-Related Results: Difficulties Related to the Internet:

This domain was ranked the 4th. It got a mean of (3.13), a RI of (62.60%) and moderate degree of difficulty. Its (6) items got the same degree of difficulty. The highest in both mean and RI was item (23) "Slow internet connection or even frequent disconnection" which got a mean of (3.50) and a RI of (70.0%), while item (25) "Lack of censorship on the internet which means easy access to sites inconsistent with our customs and traditions" got a mean of (2.77) and RI of (55.4%). For items (27, 26, 24), the RI was (62.6%, 61.4%, 55.8%), respectively. This was due to technical reasons. The Ministry of Education and that of Communications are jointly working to solve this problem by linking all schools of the Kingdom by high speed fiberglass net. A considerable part of the project has so far been accomplished, and by the end of 2011 the project will have completely been done. As a result, the number of PCs connected with the internet will considerably be increased.(Ministry of Education, 2008). Now these results agree with those of the following studies in one thing : None of them considers the slow internet connection or internet disconnection a major obstacle that hinders the internet use on the part of post graduate students in the Faculty of Educational Studies at the University of Jordan or secondary stage teachers in the UAE or the UK.(Al-Hamran, 2006; Shirawi, 2006; Al-Zahrani, 2005; Mobuslat, 2005; Al-Ajlouni, 2004; Kozma, 2004; Lia and Pratt, 2002; Hawakes et al, 1999).

III. Question 3-Related Results:

What are the major suggestions to upgrade the program from the point-of-view of graduates?

The researchers have analyzed and studied the most prominent suggestions given by graduates. They appear in table (5) below in the order of their frequency and percentage.

Table 5

Frequency and Percentage of Major Suggestions to Upgrade the (ICTE) Program

No	Suggestions	Frequency of Suggestions	Percentage of Frequency
1	Explaining in detail the Flash software for its incredible potential and its concordance with World Web developments, instead of teaching the Visual Basic and Authorware	259	84.1
2	Cancelling the MS-Project software-related part in project (1), merging all projects in one or two projects, and introducing Timer and Auto Run programs in the project's material	252	81.8
3	Merging all courses of education in just one or two courses and enriching Methods of Evaluation course with topics that focus on descriptive and analytical statistics by using the statistical packages (SPSS), and offering these courses throughout the whole academic year rather than just the summer vacation, so that teachers can apply what they had learnt of skills and knowledge promptly	247	80.2
4	Providing good anti-virus programs	243	78.9
5	Providing proper maintenance for the PCs and their accessories	238	77.3
6	Providing good furniture, such as comfortable chairs and tables	231	75.0
7	Providing modern PCs in labs	223	72.4
8	Equipping participants in the program with laptops	214	69.5
9	Focusing on the practical, rather than the theoretical, side of technology-related materials	201	65.3
10	Offering follow-up supervision and guidance for teachers in their schools, and trying to incorporate technology in their curricula	193	62.7

11	Teaching Front page software, along with that of Dreamweaver, because it is Arabic-enabled	184	59.7
12	Teaching in-detail Fotoshop software, and introducing Corel Draw and Illustrator software, as complements	150	48.7
13	Teaching Mero, Jet Audio, Video Cutter software, along with Sound Forge for the incredible benefits of this software	135	43.9
14	Resumption of teaching Ulead Video Studio software in the program	113	36.7
15	Loading the PCs with the latest editions of software programs	91	29.5
16	Reducing the number of students in classes and labs	85	27.6
17	Giving special applications in data bases by using Ms-Access program	71	23.1
18	Introducing Premier software, along with that of Movie Maker	67	21.8
19	Keeping the computer labs open for a longer time and making sure that the PCs are incessantly connected with internet	49	15.9
20	Giving an idea about programming that use the languages of VB.Net, Oracle, Cinema 4 dimension software, along with Science 64 tool bar and Smart Board program	30	9.7
21	Attracting quality teachers to work in the program	26	8.4
22	Raising the number of female teachers since the number of female students enrolled outweighs that of males	16	5.2

As table (5) above shows, graduates (teachers) mentioned many suggestions to upgrade the program, the most important of which was “explaining in detail the Flash software for its incredible potential and its concordance with World Web developments, instead of teaching the Visual Basic and Authorware”. This suggestion got the highest percentage of frequency (84.1%). The researchers attributed that to the strong desire of the study subjects to upgrade and improve their skills in implementing the ICT tools and to make use of them as much as possible in teaching. “Cancelling the MS-Project software-related part in project (1), merging all projects in one or two projects, and introducing Timer and Auto Run programs in the project’s material” came next with a percentage of (81.8%). This could be explained by the importance of reconsidering the content of project (1) and project (2) in the design stage, and stage (3): implementation of the electronic contents in a way that meets teacher's needs in the educational field. The suggestion “Merging all courses of education in just one or two courses and enriching Methods of Evaluation course with topics that focus on descriptive and analytical statistics by using the statistical packages (SPSS), and offering these courses throughout the whole academic year rather than just the summer vacation, so that teachers can apply what they had learnt of skills and knowledge promptly” followed with a percentage of (80.2%). This revealed that most study subjects were quite convinced with the importance of reducing the courses of education in the program, and focusing on just one course which is Methods of Evaluation, which is important in their profession. “Providing good anti-virus programs” came next with a percentage of (78.9%), followed by the suggestion “Providing proper maintenance for the PCs and their accessories” which got a percentage of (77.3%). This pointed out to the lack of regular maintenance for the PCs, and lack of good anti-virus programs, which would hinder teachers’ work and damage their disks. Suggestion no (22) “raising the number of female teachers, since the number of female students enrolled outweighed that of males”, however, got the lowest percentage (5.2%), proceeded by suggestion (21) “attracting quality teachers to work in the program” which got a percentage of just (8.4%). Suggestion (20) “giving an idea about programming that use the languages of VB.Net, Oracle, Cinema 4 dimension software, along with Science 64 tool bar and Smart Board program” got a percentage of (9.7%). This showed that these were very low

percentages. The other suggestions had percentages that ranged between (15.9%) to (75.0%). These percentages tackled graduates' interests, needs and work at schools, with varying degrees.

Recommendations

Based on the findings of the study, the researchers recommended the following:

1. Linking the program's objectives with the problems teacher faced in classroom teaching, trying to look for the best solutions for these problems and offering a follow-up guidance for teachers to perfect their technical skills.
2. Focusing on teaching the Flash software skills, and reconsidering some existing software, such as the MS-Project.
3. Implementing the ICTE skills in the program.
4. Checking that the PCs and their accessories in the university labs are regularly subjected to maintenance, and loading them with good anti-virus programs.
5. Increasing the number of PCs connected with the internet in state schools and loading them with multi-media programs the teachers had already studied in the program, so that they can benefit from their applications in the teaching-learning process. Moreover, trying to set up a web site for each school and to activate it by students and teachers.
6. Conducting more studies on the influence of program on teachers, and linking that with some variables.

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Editor's Note: Learning from interactive digital games attracted the attention of educators and instructional designers in the 1960's. Rand, System Development Corporation, and IBM used mainframe computers for the initial experiments. Interactive presentation benefited from teaching machines and the "intrinsic programming" of Norman Crowder, and more recently from hyperlinked media like "Hypercard" and web browser using Graphic User Interfaces (GUIs). In the Mid 1990's, the Ngee Ann Polytechnic in Singapore provided on-campus facilities where makers of computer games partnered with educators to developing digital game-based learning. More recently, the University of Southern California School of Cinematic Arts developed a similar venture.

Guidelines, Challenges, & Recommendations for Digital Game-Based Learning

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Abstract

Digital game-based learning (DGBL) has received an enormous amount of attention recently. This paper is intended to (a) synthesize current literature in related areas, (b) provide research-based guidelines/heuristics for the design of educational games through an exploratory content analysis, (c) address challenges for DGBL development and implementation, and (d) recommend areas for further research. Drawn from Bloom's taxonomy and Gagné's work in assessing different types of learning outcomes, an adapted framework examines GBL's effectiveness in terms of cognitive, affective, and psychomotor domains. Another framework is adapted from Malone's and Wishart's work combined to build a plausible basis for the content analysis.

Keywords: digital game-based learning, game-based learning, video games, instructional design, instructional development, multimedia learning, computer-assisted learning, computer-based learning

Introduction

This paper is intended to (a) synthesize the current literature related to digital game-based learning (DGBL), (b) provide research-based guidelines for the education game design, (c) pinpoint challenges for the DGBL development and implementation, and (d) recommend areas that require additional research.

The concept of computer games incorporated into school curriculum remains innovative to many of educators across various levels and disciplines, but the effectiveness of the new learning approach is worth the effort required to investigate its efficacy from a broader perspective (Pivec, 2007). Is it probably because teachers and parents are in doubt about the value of such approach to instruction? Or, as Charsky and Mims (2008) argue, games are not for anybody or in all subject content. Could this innovative approach be just another fashion statement? If the learning approach is deemed effective, what education game design guidelines, or heuristics, can we interpret from current empirical research?

The motivation for this study lies in the form of skepticism as an unconvinced lens, which originates from the author's background in instructional technology. The skeptic view is also shared by other opponents, including teachers and parents, with a less favorable attitude toward the use of computer games due to these games' nature (e.g., play). Some may consider that a congenital threat to learning. This view may be attributed to the instructional technology field's historic approach that the instructional designer first determines what performance objectives and corresponding instructional activities are concerned within a given learning context *prior to* selecting any appropriate technologies/media. With this in mind, the argument of adopting computer games in the curriculum in the first place does not appear pedagogically sound in the first place. This is because such technology adoption seems to contradict the "conventional"

instructional systems design concept, where media selection comes after performance objectives are translated into multiple instructional activities, including content presentation, learning participation, assessment, and feedback (Dick, Carey, & Carey, 2004). This technology adoption seemingly dictates the instructional design from the very beginning when performance analysis and needs assessment are conducted, just like other emerging technologies (e.g., Web 2.0). Are we, the instructional technology field, putting the cart before the horses? Or, are we thinking outside the box in this adoption of computer games in education as one may argue that the rise of a games generation (see Carstens & Beck, 2004; Gee, 2003; Prensky, 2001) is the reason behind this "revolution"?

Please note that majority of the cited journal articles (e.g., Social Science Citation Indexed Journals and others in Tier 1) in this paper are purposively selected due to their rigorous peer-review process adopted by each journal. In some cases, other documents (e.g., other refereed journals) are also sought to supplement core findings when appropriate. This careful review process will assist the reader in choosing quality literature and deciphering DGBL design rationales. Implications that arise within this paper will assist both practitioners and researchers to acquire in-depth insights and better conduct their research and development in DGBL.

Background

Games are engaging human activities (Guberman & Saxe, 2000), and the use of games is not uncommon in education (Pivec, 2007). Games are considered a popular form of playing, and playing, if introduced properly, can lead to learning (Rosas et al., 2003).

Concomitant with recent advances in technology formats, the use of educational games has become increasingly digitalized and computerized. O'Neil, Wainess, and Baker (2005) posit that when applied in a pedagogically sound manner, computer games can contribute to at least four areas in instruction: (a) complex and diverse approaches to learning processes and outcomes, (b) interactivity, (c) ability to address cognitive as well as affective learning issues, and (d) motivation for learning (p. 455). These computer games, when integrated into the curriculum and intended for specific learning purposes, are part of digital game-based learning (DGBL). DGBL is defined, in its broadest terms, as a mix of learning behavior and experience that involves the use of video/computer games in a meaningful context. In its narrow definition, DGBL is operationalized as a mix of learning behavior and experience that occurs as result of the purposeful intervention of video/computer games in a defined educational context that ties into a formal school curriculum. The former deals with a general context that may include multiple dimensions, such as education, society, and culture, whereas the latter targets learning outcomes in close relation to school curricula.

As previously mentioned, games suggest play or playing, which is a concept that concerns parents and educators (Charsky & Mims, 2008). This concern is inevitable, considering the research findings that show a strong correlation between violent video games and negative behaviors (e.g., aggression) according to Anderson et al. (2008). Reflecting user patterns and concerns, Dondi and Moretti (2007) identified three "user" positions: (a) those who use DGBL as an integral part of the curriculum, (b) those who use DGBL as part of the curriculum, and (c) those who never use DGBL. Dondi and Moretti contemplate a need for the field to approach all three, particularly the last two groups. This is because both groups remain, to a varying degree, unconvinced about the adoption of DGBL. One may argue that not all digitally-based games are violent or connote a negative influence on human behaviors. To give a benefit of the doubt, at least for the moment, let's assume there is a slight possibility that DGBL may or can contribute to learning outcomes. To further the discussion of DGBL, Arnseth (2006) makes a distinction between two concepts, playing to learn and learning to play. The concept of playing to learn emphasizes learning, where playing (computer) games is treated as the means to an end (i.e., learning). Conversely, the

concept of learning to play places an emphasis on game play, wherein learning is considered one part of a summative human activity (i.e., mastery of a game play). Each of the two concepts leads to a different research methodology. According to Arnseth, playing-to-learn type of research tends to be experimental or involves correlational methods while learning-to-play studies are likely to be qualitative in nature.

Taking a different view of DGBL, Hayes (2008) identifies two major paradigms for examining gaming in various disciplines, such as cultural studies and anthropology. The two paradigms differ in the context (i.e. in-the-school vs. out-of-school). Generally speaking, Hayes refers the in-the-school contexts to some studies that target learning outcomes in the formal education system. In such instances, computer games, both commercial off-the-shelf (COTS) and self-developed, are considered motivators, and students' academic content knowledge and skills are measured. She refers the out-of-school contexts to other studies that concentrate on gains of knowledge, skills, and attitudes outside formal educational programs. In this case, researchers may study any increases of cognitive attributes (e.g., social problem-solving) with the intervention of computer games through socialized activities (see the work by Kim, Park, & Baek, 2009 for an example). Despite the fact that the aforementioned dichotomy may simplify the complexity of the research paradigms, this identification provides a foundation for the classification and understanding of DGBL.

DGBL has certainly come a long way and received the general public's attention, a phase where it has previously never been. This achievement is attributed to (a) the rich and growing literature contributed by its advocates, (b) rising of "Net Generation" (those born in 1980 and onwards), and (c) growth of the game industry (van Eck, 2006). These three attributes appear inter-related. The Net Generation could encourage a booming game industry. When more game play occurs, more researchers in different areas would dedicate themselves to the investigation of such phenomenon on individual, group, and societal levels, which may lead to a rich and growing literature pool. Van Eck (2006) encourages the field of DGBL to go beyond the "Yes/No" question (as in, "is DGBL effective?") and pursue two aspects of the learning: (a) causes of engagement and effectiveness and (b) context or conditions under which the learning is deemed engaging and effective. Along these lines, the topic of this paper suggests, with good faith, a primary focus on empirical evidence of learning outcomes of DGBL. The attempt is to extract a list of successful design features through a systematic review of sought DGBL literature. To conduct a more focused examination, the present study adopts the narrow definition of DGBL with a specific emphasis on DGBL and its effectiveness in the context of formal school curriculum as previously stated. And, the term, "digital game-based learning" (DGBL) is used interchangeably with "game-based learning" (see Ebner & Holzinger, 2007; Squire, Giovanetto, Devane, & Durga, 2005).

Effectiveness of Computer Games in Education

To determine whether computer games benefit teaching and learning in the school, these games need to be utilized in environments where the games' primary purpose is to achieve mastery of specified instructional objectives. Most game studies focus on the benefit issue of achieving instructional objectives, particularly in a formal education context (Hayes, 2008). Sauvé, Renaud, Kaufman, and Marquis (2007) suggest that this deployment be examined in at least three domains: cognitive, affective, and psychomotor. The framework of the three predominant domains of learning is supported by the work of Bloom and his colleagues as well as Gagné's (as cited in Smith and Ragan, 2000). To see an example of how Gagné's nine learning events are applied to the design of DGBL, please see the work by Hirumi, Appelman, Rieber, and Van Eck (2010). Apparently, this framework seems to lean more toward the side of cognitive theories of learning than that of ecological learning theories. The reason is two-fold. First, it is made to

accommodate the adopted narrow definition of DGBL. Second, the decision is to concentrate on the learning outcomes that are relatively more measurable and more observable than others. Findings are summarized as follows.

Using computer games as an instructional intervention, cognitive gains are evidenced in prior research. However, the results seem elusive. Segers and Verhoeven (2005) reported an immediate knowledge gain in the language arts objectives of rhyming and grapheme association in Dutch kindergarteners. Using an ANOVA procedure, Sung, Chang, and Lee (2008) showed the usefulness of computer games in the (re)development of superior-level hierarchical taxonomic concepts. Rosas et al. (2003) asserted that first and second graders who use custom-made Nintendo's Gameboy-type games as the integral part of curriculum outperform those that do not have any contact with that type of game technology in areas of mathematics, reading comprehension, and spelling. There is, however, literature that also shows a non-significantly-different result in cognitive gains (Ke, 2008a, 2008b; McDonald & Hannafin, 2003).

Computer games also contribute to the affective domain of learning to a significant degree. A quantitative study by Ke (2008a, 2008b) indicated that the participating elementary students in a number of Pennsylvania schools developed more favorable attitudes toward mathematics learning, although cognitive and meta-cognitive gains were not supported by the results. Wang (2008) claimed that fifth graders in Taiwan who used Web-based games for the purposes of formative assessment perform better than those who used Web-based non-games in terms of the number of times those students participated in the assigned practice system. This result suggested that learners in the game-based practice system be more inclined to use computer games to practice taught knowledge before summative assessment. The mixed design study by Rosas et al. (2003) also reported significant attention gains in the presence of Nintendo-like video games. This finding indicated that the lower level graders who play educational games tend to have a more positive attitude toward learning than their non-gaming counterparts.

Though there is little research on computer games that lead to motor skills increase in academics, a high-profile study from the medical field by Rosser et al. (2007) may shed some light on the influence of computer games on motor skills. Rosser et al. stated that surgeons who play video games more than three hours a week at some point in the past performed better than their colleagues who do not play games at all in regard to laparoscopic skills and suturing capability. The significant performance is as a result of 37% fewer errors and 27% faster completion. An investigation from the health-related field, studied by Baranowski, Buday, Thompson, and Baranowski (2008), supported the argument that serious video games can exert a positive effect on health-related behavior change in areas, such as dietary change, fitness attainment, and physical activity improvement. Findings of prior studies (Betker, Desai, Nett, Kapadia, & Szturm, 2007; Jannink et al., 2008) in the physical therapy area are also congruent with this argument. Furthermore, Baranowski, Buday, Thompson, and Baranowski contended that video games are likely to be effective in improving human performance on either of two possible conditions. First, behavior changing procedures, such as goal setting and attaining, are incorporated in the game play. Second, the use of engaging stories which involve behavior-change concepts, such as the conflict between a protagonist and an antagonist, is embedded in the video game. Acknowledging that not all motor skills gains are always positive, a longitudinal study by Anderson et al. (2008) on the effect of violent video games on aggression reported that (a) habitually playing video games causes later (within a range of three to six months) aggressive behaviors, (b) the caused aggression is more significant on adolescent boys than girls, (c) present physical aggressiveness can predict later physical aggressiveness, and (d) the previous results hold true across two distinct cultures (i.e., the United States and Japan). All these results aforementioned echo the findings of another similar study on aggressive behaviors, conducted by Konijn, Nije Bijvank, and Bushman (2007), using Dutch adolescent boys ($N = 99$, mean age = 14 yrs, SD = 1.05).

This preliminary literature review summary suggests that there is apparently an uncertainty concerning the effectiveness of GBL with regard to students' cognitive gains. The summary also fosters a need to refocus on attempt to synthesize the game design guidelines/heuristics and to concentrate on cognitive and affective gains of GBL, as suggested by Squire, Giovanetto, Devane, and Durga (2005). With an emphasis on cognitive and affective domains of learning, Vogel et al. (2006) verified a significant effect of computer games and interactive simulations on both cognitive and affective outcomes regardless of learners and learning situations. When factored in moderator variables, a fuller picture of the influences of these computer applications (i.e., games and simulations) on learning is presented (see Table 1).

Note. Moderator variables are divided by the researchers into three groups, (a) type of activity, (b) population (including Gender, Age, and Users), and (c) computer characteristics (i.e., Control and Realism).

This meta-analysis is deemed insightful, and its findings help build a baseline for the present study. According to Vogel et al. (2006), 248 studies were initially sought from electronic databases (e.g., PsycInfo), dissertation abstracts, and references lists of collected literature. Thirty-two of the reviewed studies were then selected for further analysis in order to fulfill the set criteria. Criteria of selecting these studies are as follows:

1. Identify either cognitive or attitudinal (affective) gains as dependent variables
2. Compare the game or interactive simulation group to a control group (a.k.a. traditional instruction)
3. Involve three moderator variables, type of activity, population, and computer characteristics.

Out of the selected 32 articles, about one forth originate from Social Science Citation Indexed journals, (e.g., British Journal of Educational Technology, and Journal of Computer Assisted Learning), and the most recent article sought was published in 2003. The study, indeed, serves as a critical baseline for understanding GBL up to the present time, yet more recent articles need be reviewed to contribute to the literature of game-based learning, considering the three attributes (van Eck, 2006), noted previously.

It is worth noting that (computer) games, simulations, and simulation games (a.k.a. the "blended approach") seem to be defined in a dissimilar way in prior studies (e.g., O'Neil, Wainess, & Baker, 2005). Sauvé, Renaud, Kaufman, and Marquis (2007) define a game as "a fictitious, whimsical or artificial situation in which players are put in a position of conflict" (p. 253). According to these four Canadian researchers, games (a) afford a type of virtual environment through computer programs, (b) are rule-based, (c) involve a ultimate goal to win through a given challenge(s), (d) may not mimic real life events, and (e) allow their players, by taking an artificial character, to compete against each other on an individual or a group level, or against the computer game program itself.

For clarity in usage of terminology, Sauvé, Renaud, Kaufman, and Marquis define a simulation as "a simplified, dynamic and precise representation of reality defined as a system" (p. 253). Their definitions of games and simulations appear to be endorsed by Gredler (as cited in O'Neil, Wainess, and Baker, 2005). When it comes to the differences between a game and a simulation, Sauvé et al. argue that a game differs from a simulation in two aspects. First, the goal of a game is always concerned with some form of victory. Second, the feature of a game does not resemble reality. Neither of these aspects sustains any pure form of a simulation. Furthermore, O'Neil, Wainess, and Baker (2005) emphasize the difference from another perspective in that a game has a linear goal structure where an attainment of a predetermined goal signals an end of the game until it is intentionally restarted whereas a simulation has a non-linear goal structure where its users are able to manipulate the input to a simulated system in order for a preferred output.

Table 1
Results of Meta-Analysis Study by Vogel et al. (2006)

Moderator Variable	Subgroup	Question Studied	Result	
			Significant	Reliable
Gender	1. Male 2. Female 3. Both 4. Unspecified	When across genders or gender was not reported, are game and interactive simulation more effective (than the control group)?	Yes	Yes
		When only "Female" is considered, are game and interactive simulation more effective (than the control group)?	Yes	No, due to low fail-safe number
		When only "Male" is considered, are game and interactive simulation more effective (than the control group)?	Not reported due to few studies	N/A
		When comparing "Female" to "Male," are game and interactive simulation more effective in one group than the other?	No	No, due to low fail-safe number
(Learner) Control	1. Student 2. Teacher 3. Computer 4. Unspecified	When only "Computer" (e.g., artificial intelligence and decision trees) is considered, are game and interactive simulation more effective (than the control group)?	No	No, due to low fail-safe number
		When only "Student" is considered, are game and interactive simulation more effective (than the control group)?	Yes	Yes
Type of Activity	1. Interactive Simulation 2. Game 3. Unknown/ unspecified	When only "Interactive Simulation" is considered, are game and interactive simulation are more effective (than the control group)?	Yes	Yes
		When only "Game" is considered, are game and interactive simulation are more effective (than the control group)?	Yes	No, due to low fail-safe number
		When the combined group of "Interactive Simulation" and "Game" is considered, are game and interactive simulation are more effective (than the control group)?	Yes	No, due to low fail-safe number
Age	1. Preschool (< 5 yrs) 2. Elementary (Grades K-5) 3. Middle (Grades 6-8) 4. High (9-12) 5. College undergraduate 6. Adult (25 yrs or older) 7. Unknown/ unspecified	When the combined group of "Preschool," "Elementary," "Middle," and "High (School)" is considered, are game and interactive simulation are more effective (than the control group)?	Yes	Yes
		When the combined group of "College" and "Adult" is considered, are game and interactive simulation are more effective (than the control group)?	Yes	Yes
Realism	1. Photo-realistic 2. High-quality Cartoon-like Pictures 3. Low-quality Programmed Pictures 4. Unknown/ unspecified	When only "Photo-realistic" is considered, are game and interactive simulation more effective (than the control group)?	Yes	Yes
		When only "High-quality Cartoon-like Pictures" is considered, are game and interactive simulation more effective (than the control group)?	Yes	No, due to low fail-safe number
		When only "Low-quality Programmed Pictures" is considered, are game and interactive simulation more effective (than the control group)?	Yes	Yes
		When only "Unknown/unspecified" is considered, are game and interactive simulation more effective (than the control group)?	Yes	Yes
Users	1. Individual 2. Group 3. Both 4. Unspecified	When only "Individual" is considered, are game and interactive simulation more effective (than the control group)?	Yes	Yes
		When only "Group" is considered, are game and interactive simulation more effective (than the control group)?	Yes	Yes

Vogel et al. (2006) define games and simulations in quite a similar fashion. According to Vogel et al., a (computer) game is defined as an activity that has "goals, is interactive, and is rewarding (gives feedback)" and a (interactive) simulation is an activity that "must interact with the users by offering the options to choose or define parameters of the simulation then observe the newly created sequence rather than simply selecting prerecorded simulation" (p. 231). Vogel and her associates have yet to define a simulation game using their own terms. Likewise, the study by Sauvé et al. and the one by O'Neil et al. do not further the discussion on the hybrid environment (i.e., simulation games). Regardless, Kryukov and Kryukova (as cited in Wall and Ahmed, 2008) define simulation games with three fundamental elements:

1. Any simulation game always reflects reality.
2. A simulation game is embodied in a form of social communication.
3. The evaluation of reality [is] together with self-evaluation and reflection (p. 1386).

In other words, a simulation game refers to a hybrid approach by which its players interact in a simulated reality that emulates, evaluates, and reflects on socialized activities. However, it should also be noted that the degree to which the two approaches (games and simulations) are blended for a given purpose is not yet defined. The reader may wish to refer to the work by Virvou and Katsionis (2008), Virvou, Katsionis, and Manos (2005), and Wishart (1990) for examples of a simulation game.

For the purpose of this paper, the investigation excludes studies on pure simulations (see Holzinger, Kickmeier-Rust, Wassertheurer, & Hessinger, 2009; Korakakis, Palyvos, & Spyrellis, 2009; Ligorio & Van der Meijden, 2008) and only addresses GBL with respect to games and simulation games as the term, game-based learning, literally suggests.

Design of Education Games

Drawn from the investigation done thus far, let's turn to another round of review of relevant literature that may inform us on the design of effective and affective education games. This refocused review is based on three criteria: (a) published in Social Science Citation Indexed Journals pertaining to the education/instructional technology area, (b) indicating certain form of empirical analysis of the collected data in cognitive and/or affective domains of learning, (c) published in the year of 2003 or later. Descriptors used include games, game-based learning, video games, and computer games. After the screening review process, 11 journal articles are selected for further analysis, which are included in the primary pool. Remaining articles are used to supplement guidelines to be extracted from the primary tool when applicable. The remainders are named the secondary pool. In essence, the 11 articles cited confirm the effectiveness of education games in regard to cognitive and affective domains of learning (see Table 2), which is congruent with the overall findings of the meta-analysis study by Vogel et al. (2006).

In Table 2, the three articles that do not report a significant gain in learning achievement could have been some validity issue of the adopted assessment tools (see Ebner & Holzinger, 2007 and Ke, 2008a) or the possible Hawthorn effect (see Ke, 2008b). The four articles that are marked as "Not measured" identify a pre-determined or research-informed decision to adopt games in the treatment. Kim, Park, and Baek (2009) argue that a massive multiple online role-playing game (MMORPG) itself encourages learner's/player's attention and curiosity during game play. Paul, Hollis, and Messina (2006) count on games for being engaging and motivating. Segers and Verhoeven (2005) develop fun games (e.g., coloring and listening songs) to engage kindergarteners. Sung, Chang, and Lee (2008) reason that games stimulates learners' interest in the content through game play and enables designers to build a media-rich learning context. Consequently, these researchers go beyond the affective domain and investigate games' effect on learning achievement, suggesting they acknowledge games' affective influence.

Table 2
Overview of GBL Effectiveness by Author

Author	COTS	Genre	Significant Cognitive Gain	Significant Affective Gain
Ebner and Holzinger (2007)	No	Simulation Game	No	Yes
Ke (2008a)	No	Games and simulation games	No	Yes
Ke (2008b)	No	Game and simulation games	No	Yes
Kim, Park, and Baek (2009)	Yes (simulation game)	Simulation Game (*Gersasng*, a MMORPG)	Yes	Not Measured
Papastergiou (2009)	No	Game	Yes	Yes
Paul, Hollis, and Messina (2006)	No	Game (modeled on *Jeopardy* and *Hollywood Squares*)	Yes	Not Measured
Rosas et al. (2003)	No	Games	Yes	Yes
Segers and Verhoeven (2005)	Unspecified	Games	Yes	Not Measured
Sung, Chang, and Lee (2008)	No	Games	Yes	Not Measured
Virvou, Katsionis, and Manos (2005)	No	Simulation Game	Yes	Yes
Wang (2008)	No	Game (modeled on *Giant Riches* and *Who Wants to Be a Millionaire*.	Yes	Yes

Let's now attend to key game design features of these studies. Specific attention is paid to the information of the game(s) adopted in each study that is typically recorded in the Method section of each paper. In a small number of studies (e.g., Rosas et al., 2003), the information is provided in the Introduction/Background section. Drawn from Malone's (1981) three-factor model (also as cited in Prensky, 2001) and Wishart's (1990) study on the control factor, an analysis scheme is composed in an effort to build a plausible basis for this exploratory content analysis. Next, the scheme is briefly introduced. Malone's three factors: challenge, fantasy, and curiosity are frequently cited in the literature (e.g., Yu, Chang, Liu, & Chan, 2002; Charsky & Mims, 2008; Nicol & Anderson, 2000). Challenge can be associated with concepts, such as goal, difficulty level, and scores. Fantasy is related to imaginary ideas (e.g., role playing, story, representation, and metaphor). Curiosity is usually concerned with unexpected thoughts afforded by visual and

audio effects in games. Wishart (1990) expands Malone's work by adding another factor related to designing education games, control. Wishart reports that "the amount of learning from an educational computer game may be significantly increased by giving the learner control over the action, and further enhanced by increasing the complexity of the game with color graphics or providing challenges with a high score table" (p. 149). In Wishart's study, complexity refers to the use of (color) photos; challenge is represented in a score table upon completion of the game play; control is given by two routes (paths). After the content analysis (with a 79.2% inter-rater reliability rate), two additional themes are identified. As seen in Figure 1 below, six major design themes emerge from the attended information of adopted games.

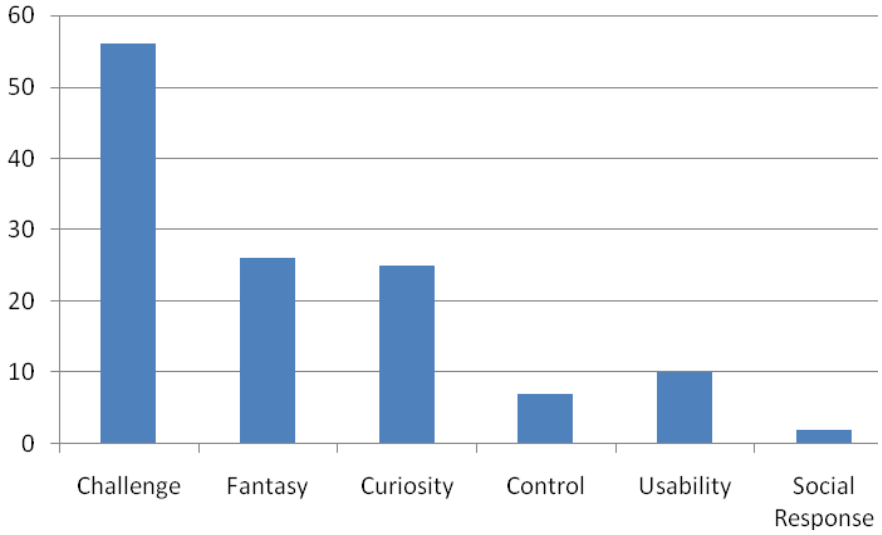

Figure 1. **Frequencies of occurrences of emerged themes.**

Two additional identified themes are usability and social responsiveness. Both features are also supported by the GBL literature. Usability primarily deals with the concept of ease of use, a concept that is commonly discussed in management information system field. Davis (1989, 1993) developed a Technology Acceptance Model (TAM) model that posits that the acceptance of an information system project (e.g., the Blackboard course management system) depends on users' attitude toward the system, which is then caused by both users' perception of how useful the system is (i.e., usefulness) and perception of how easy the system is to use (i.e., ease of use) (see Pan, Sivo, Gunter, & Cornell, 2005; Sivo, Pan, & Hahs-Vaughn, 2007). Above all, ease of use is an exogenous variable (similar to an independent variable), suggesting it has a direct or indirect causal effect on all the other variables mentioned early. Social responsiveness is addressed in a study by Barab, Thomas, Dodge, Carteaux, and Tüzün (2005), where they transcend their commitment to society into a violence-free (e.g., no guns) video game design project (i.e., Quest Atlantis). According to Barab et al. (2005), a socially responsive game needs to interact with players and further prepare them for responsible citizens, who value their own culture and appreciate that of others'.

Keeping in mind this brief discussion of the six emerged themes from the content analysis, let's attempt to extrapolate a list of design features (i.e., heuristics) from the analysis (see Appendix A for more information of the analysis) by theme (see Table 3), followed by a discussion, based on studies in the primary pool and supported by those in the secondary pool.

Table 3
Emerged Themes and Heuristics

Theme	Heuristics
Challenge	1. Set a two-fold goal at equal weight: playing and learning. 2. Define difficulty in progressive levels that tie into target knowledge (hierarchy). 3. Use scores to provide situation awareness and inform decisions. 4. Incorporate speed in game mechanisms for non-kindergarteners. The faster-paced and the preciser, the more engaged.
Fantasy	5. Allow learners to identify with the content within the game using a storyline that they can relate to in real life or fantasy.
Curiosity	6. Timely feedback is necessary, and use direct feedback on knowledge level content and in the context where dichotomy is seen. 7. Design the interface in a visually pleasant form, which does not need to be fancy.
Control	8. Provide learner control in the game play for drill and practice purposes.
Usability	9. Address "ease of use" in the game design, when the game is intended for individual use.
Social responsiveness	10. Exclude violent and sex-related content.

Playfulness is commonly associated with computer games. Arguably, one may assume that the fundamental characteristic, play, in any computer games, also applies to education games, considering the commonality between the two variations (Bottino, Ferlino, Ott, & Tavella, 2007; Ebner & Holzinger, 2007). The challenge aspect of an education game is considered a vital characteristic of motivation. Challenges, when planned well and embedded in games of high interest and appeal for the intended audience, can promote learning (Rice, 2007). Thus, this challenge feature must be planned properly. A feature of a virtual competitor or player may keep the game challenging (Kiili, 2007). Perhaps limited time, more work involved, or rule change is involved in higher levels of difficulty. Because the 11 studied education games, in most cases, are developed for school use (except for Kim, Park, and Baek, 2009), these games always communicate two distinct foci: learning and playing. One of creative ways to address both foci in the game design is to tie the target content into defined difficulty levels. Similar to a challenge, the concept of difficulty in education games is usually characterized by levels. O'Neil, Wainess, and Baker (2005) regard these levels as goals. The end of a goal signals the beginning of another goal or goals. Difficulty is also translated into episodes (Ke, 2008b). Furthermore, competition suggests a contest or a game. Competition in GBL is frequently results in a winning/losing situation.

In some instances, competition is quantified by scores or points. This information is used for monitoring performance and intended for better decisions (e.g., Kim, Park, and Baek, 2009). The faster and the greater the scores one receives, the more engaged s/he becomes (e.g., Wang, 2008). In other types of GBLs, competition ends with a resolved problem or an accomplished mission

(see Kiili, 2007). An important optional feature in GBL--anonymity--can offset the negative impact of adverse or excessive peer competition (Yu, Chang, Liu, & Chan, 2002). In short, a game with unsolvable challenges or problems may discourage the learners from the beginning of the game play, whereas a game without any challenge or the difficulty level is below learners' ability or computer literacy may also bore its players.

The story or narrative developed is able to help learners create a fantasized construction of self (e.g., role-playing a pilot or a cashier in Ke, 2008a and 200b). In other cases, fantasy is built into the content (e.g., maze games) to illustrate computer memory concepts in Papastergiou, 2009 and a game on taxonomic concepts where kindergartners try to help a fantasized or imaginary farm owner pack stuff to move in Sung, Chang, & Lee, 2008). When game activities are presented in a context in which learners are able to relate to, developed games may stand better chances of engaging the learners. With this in mind, Martens, Gulikers, and Bastiaens (2004) remind us that this imaginary learning/gaming context still needs to be reasonably "realistic."

Prior research in computer-assisted learning (and basic instructional design theory) indicates that feedback is one of the most effective design features of a multimedia learning object (Morrison, Ross, & O'Dell, 1995). In the design of GBL, the feedback feature remains applicable. A timely feedback is necessary. Direct feedback seems sufficient to cope with knowledge level content (e.g., Wang, 2008) and when a yes/no or true/false decision is made by the learner (e.g., Sung, Chang, & Lee, 2008). "Direct feedback" used by Bottino, Ferlino, Ott, and Tavella (2007, p. 1280) in a study on developing reasoning abilities combines different modes, including verbal (e.g., text) and nonverbal (e.g., sound) seems effective. The "money ladder" in McDonald and Hannafin's (2003) study, inspired by a popular TV show, *Who Wants to Be a Millionaire?* is just another example of providing elaborate feedback to show learners' progress. However, Vogel et al. (2006) state that visual effects do contribute to learning regardless of their levels of fidelity. Related to the concept of feedback, hints that come by request or as a surprise are also used in education games in the literature. These hints can appear in a form that reduces the test question options to a minimal number, i.e., Prune Strategy or in another form that tells what other game players respond to a particular test question, i.e., Call-in Strategy (Wang, 2008). Both strategies are drawn from the TV show, *Who Wants to Be a Millionaire?* Ke (2008b) adopts a similar just-in-time hint to guide learners in the navigation. Also, a random hint is evidenced in the literature for recollection purposes (see Virvou, Katsionis, & Manos, 2005).

Learner control allows for a democracy for learning by transferring the power of constructing knowledge from the instructor or a learning system to learners themselves. Wishart (1990) reports that given choices of learning routes or paths in an education game, learners report better learning performance than their counterparts not given such choice. Virvou and Katsionis (2008), in support of learner control, argue that learners are likely to avoid situational distractions in GBL when given options to customize the game settings. Having said this, in order to allow for learner control, learners must be able to possess the basic structure of the content; otherwise, the game system (rule-based) should take control (e.g., Segers & Verhoeven, 2005; Yu, Chang, Liu, and Chan, 2002). That is to say, learner control is paramount when the learners are not entirely unfamiliar with the content structure or after they receive some guidance from the system or the instructor (see Kirschner, Sweller, & Clark, 2006).

In game design, ease of use is a concept that appears to draw researchers' attention in terms of the game structure (e.g., Bottino, Ferlino, Ott, & Tavella, 2007; Ebner & Holzinger, 2007; Papastergiou, 2009; Kim, Park, & Baek, 2009). Despite the effectiveness of their adventure or puzzle game using virtual reality, VR-ENGAGE, Virvou, Katsionis, & Manos (2005) are concerned about possible usability issues that occur for inexperienced learners when the instructor (as GBL facilitator) is not available or learners are working through the game by themselves. A follow-up study targeting the usability issues by Virvou and Katsionis (2008)

suggests that ease of use issues will be likely to cause distractions for learners. They suggest ease of use issues should be resolved prior to further instructional implementation in spite of the likeability of the education game.

Some GBL researchers place a unique emphasis on a socially responsible approach to computer game design. Supported by the study by Barab, Thomas, Dodge, Carteaux, and Tüzün (2005), the content analysis mentioned earlier in this paper shows evidence of considering non-violence (e.g., Virvou, Katsionis, & Manos, 2005) and gender equity (e.g., Papastergiou, 2009) in the design. Although one may argue that people may learn from a violent game (see van Eck, 2006), the negative effect of such games on human behaviors is confirmed (e.g., Anderson et al., 2008).

The 10 game design heuristics based on the content analysis seem endorsed, to the most degree, by Prensky (2001) in his five cited GBL principles. His five principles are (p. 179):

> Is this game fun enough that someone who is not in its target audience would want to play it (and would learn from it)?
>
> Do people using it think of themselves as "players" rather than "students" or "trainees?"
>
> Is the experience addictive? Does it produce great "word of mouth" among users? That is, do users rush out after they try it and tell their colleagues or classmates "You've got to try this—it's "way cool." Do users want to play again and again until they win, and possibly after?
>
> Are the players' skills in the subject matter and learning content of the game—be it knowledge, process, procedure, ability, etc.—significantly improving at a rapid rate and getting better the longer he or she plays?
>
> Does the game encourage reflection about what has been learned?

These five questions are intended for game designers to constantly remind themselves in the design and development of education games. The questions are expected to address two fundamental dimensions: engaging (Steps 1-3) and learning (Step 4-5), with a philosophy in mind that playing comes first and learning later. Prensky argues that if a computer game is not engaging, then the game becomes no different from Web-based instruction (assuming the game is Web-based). The two dimensions are expected to constantly develop and counterbalance each other and lead to maximum learning outcomes. Both the heuristics and the principles address the dimensions that Prensky argues for any effective education game. The heuristics extend the focus and further address two other concepts, usability and social responsiveness.

Gredler (2004) sets the following five criteria for the design of education games: (p. 572)

- Winning should be based on knowledge or skills, not random factors.
- The game should address important content, not trivia.
- The dynamics of the game should be easy to understand and interesting for the players but not obstruct or distort learning.
- Students should not lose points for wrong answers.
- Game should not be zero-sum exercises.

From Gredler's perspective, games are structured activities. If one player/learner follows a set of rules, then winning (of the game) is determined by a calculated experience, not by chance. The content of the game consists of both surface structure (e.g., point and click on the screen) and deep structure (e.g., make a conscious decision to take an action through an active, thinking process). While learners are able to identify with the narrative of the game, which enhances the sense of fantasy, the usability issues should be resolved to prevent distractions. On the other hand,

she discourages double penalty, but encourage partial credit in game play, to dissolve any potential negative psychological impact of the game on learners/players. Gredler's criteria, in this sense, are somewhat different from the researched-based 10 heuristics.

Challenges for the Education Games Development

The 10 heuristics are intended to reflect current research findings in a hope to show some promise in the computer game design. If we view these heuristics from multiple perspectives, we may be able to see what challenges practitioners are faced with.

Developing a game that encompasses two distinct foci: engaging and learning (Prensky, 2001) is a challenging task. The goal of this task is essentially (re)packaging "useful" content (learning) in the game play (engaging) or seeking "the synergy between pedagogy and engagement in DGBL" (van Eck, 2006, p. 18). Some researchers manage to tie the game design to the knowledge hierarchy of a given content area in devising an ability-appropriate system (e.g., Sung, Chang, & Lee, 2008; Ke, 2008a, 2008b). In this case, the lower level (subordinate) skills are fit for simpler game activities or those introduced earlier in the play while the higher level (superordinate) skills are embedded into relatively difficult activities. This ability-appropriate system can also resolve motivation issues (e.g., boredom or frustration as a result of the game play that is either too easy or too difficult, as suggested by Inal and Cagiltay, 2007). Additionally, common features of games (e.g., scores and fast pace) may possibly render the line between engaging (i.e., playing) and learning blurry (see Paul, Messina, & Hollis, 2006). However, more heuristics are needed to assist designers in developing education games that are both easy to use and useful.

The storyline used in education games is intended to create an imaginary world in favor of learning and engaging. Kim, Park, and Baek (2009) adopted a commercial off-the-shelf (COTS) game, where players would battle for better resources and higher levels to win the game and become a wealthy merchant. As the game proceeds, players are supposed to learn concepts of market economy. This use of a COTS game suggests a good match between engaging and learning. Because developing games specifically for school use is hardly an easy job, as previously mentioned, advocates (e.g., Gee, 2003; Prensky, 2001) have proposed the use of COTS games in the school curriculum as a viable solution from the economic viewpoint. Despite creation of a clear and feasible procedure of game selection process, there still remain decisions (or undefined areas) to be made by designers/instructors, such as the level of student responsibility for the game-generated content in regard to constructivist learning (van Eck, 2006) and the effect of game-based course content on standardized tests (Charsky & Mims, 2008).

Curiosity may entail feedback. An immediate feedback capability is a common practice in the design. Both direct feedback and elaborate feedback mechanisms are mentioned in the literature (e.g., Papastergiou, 2009; Sung, Chang, and Lee, 2008). Intuitively, direct feedback (e.g., yes/no or right/wrong) is used whenever there are only two options upon which to decide. This type of feedback is also found effective when related to knowledge level (i.e., the lower level) through a drill and practice game session (see Wang, 2008). The precise manner is as to how elaborate feedback is devised in GBL seems unknown (see Sung, Chang, and Lee, 2008). That process may need further definition using heuristics. Appealing visual and audio effects also evoke curiosity. Ebner and Holzinger (2007) use a red bar to show the remained time, part of an interface, both believe, compensates for the boring content. Virvou, Katsionis, and Manos (2005) adopt an interface that is comparable to that is found in COTS games, a practice also favored by Rosas et al. (2003) and Tüzün (2007). Knowing all levels of realism do contribute to learning (Vogel et al., 2006), designers still seem to embrace the myth of "the more realistic, the better."

Rooted inherently in the constructivist approach to instruction, the practice of allowing learner control equates to the teacher sharing the power of knowledge construction with the learners. By

doing so, learners are enabled to choose a learning path as they see fit (e.g., by customizing the game as described by Nicol & Anderson, 2000). If these learners are not "able" (or "capable") to make the decision about which learning route to take, should there be any "default" route pre-set or otherwise embedded in the first place? If so, what route would it be from the designer's perspective?

One of the heuristics described earlier is concerned with usability of the game design. Usability testing in this case mainly addresses how easy a given education game is perceived by its target end-users (see Nielsen, 2000). Simple game design that is less complex and has a simple storyline may work fine for some target audiences (see Papastergiou, 2009). However, boredom can be a concern if the game is extremely simple or not sufficiently engaging (Inal & Cagiltay, 2007). Given the plethora of pressures on teachers and designers by the gaming community and its producers, how do game designers include usability testing in the development process (e.g., formative evaluation or alpha testing) with limited resources? This may require a careful planning and coordination ahead of time depending on needed resources available.

As social responsiveness becomes a pervasive concept (Barab et al., 2005; Virvou, Katsionis, & Manos, 2005), a socially responsible citizen would ideally want to assume the responsibility for a better, more positive future. This philosophical statement, while noble and we hope, desirable, is not uniformly shared by all as having a high priority. This conflict or values struggle can (and often does) cause extra distractions from the game design for the designers.

Conclusion

The goal of this exploratory study was to seek support from relevant literature in the hope to extrapolate a list of GBL design heuristics. With an emphasis on research findings of the most recent literature in GBL, the present inquiry: (a) synthesized literature in several relevant areas, (b) suggested research-based guidelines/heuristics for the design of educational games, (c) addressed key challenges for the GBL development and implementation, and (d) recommended areas for further research effort. This paper starts with a background that describes how GBL is regarded in the literature, followed by an account of the effectiveness of GBL in terms of three distinct learning domains. To get more focus, a review of GBL literature with a list of set criteria was conducted in an attempt to extract a list of game design heuristics. As a result, 10 heuristics are identified and further discussed, mainly using studies from the primary pool as the argument base and the rest of the sought materials as additional support. Challenges for education game designers are proposed by taking a critical thinking approach to the identified heuristics.

The author attempts to propose a list of design heuristics to assist education game designers in doing an efficient job. Cautions must apply when using heuristics, though. This is partially because GBL is a fast-growing (and wildly popular) instructional milieu. As technology advances further, heuristics are expected to evolve and expand in researchers' quest for significance, new directions, and adaptations to what is fast becoming the "traditional learning environment" for the new millennium. Because of the small sought pool of literature (even though the list is supported by other studies), much more research remains to be uncovered. Given all that has been discussed thus far, the author now concludes the paper with the following recommended areas for further research.

The definition of difficulty is unknown across the board. McDonald and Hannafin (2003) define difficulty in two dimensions: content recency (e.g., content at previous grade level vs. content at the present grade level) and content details (e.g., specific content vs. general content). In most GBL studies, the significance of the difficulty concept is acknowledged; however, more attempts ought to be made to further define the concept and how it is incorporated in the game design as one aspect of game design challenge.

Education games allow for repeated trials while learners re-engage and manage challenges to progress toward success (Sung, Chang, & Lee, 2008; Wang, 2008). Allowing, by design, the opportunity for repeated trials and its subsequent effect on learner efficacy needs more research dedicated to this area.

While learner control may offset navigation distractions attributed by a complex education game, an excessive freedom of "learning control" that is enabled by allowing multiple inputs from users can potentially increase navigation (mental) efforts and consume limited internal (cognitive) resources (Kirschner, Sweller, & Clark, 2006; Mayer & Moreno, 2003), which may lead to (a) teacher guidance and occasional unintentional interference and (b) an adverse effect on learning.

The human cognitive load concerns game developers for two primary reasons: (a) GBL, which involve problem solving or higher order thinking skills, may tax more working memory (O'Neil, Wainess, & Baker, 2005), and (b) GBL, to compete against commercial games, may adopt the interface that shows complexity and sophistication (Virvou & Katsionis, 2008). To prevent cognitive overload, O'Neil, Wainess, and Baker (2005) recommend the use of navigation maps for scaffolding purposes, also concurred by Virvou and Katsionis (2008).

Considering increasing teachers' workload in GBL, to what degree is learner control integrated into an education game that requires minimal interference from the teacher? Also, acknowledging the limited internal capacity of human learners, how is cognitive load calculated in the design and development of education games that afford the maximum learning outcome? This question further introduces another issue germane to multimedia learning design. When the level of realism or fidelity intersects the maximum learning gains in GBL remains unknown. Can a saturation point be reached should there be one, as proposed by McElroy and Pan (2009)?

Due to a multiplicity of societal and technological factors, the integration of education games into classroom instructional activities will produce and is producing a synergic effect of peer discussions about learning in general (Segers & Verhoeven, 2005). While anecdotal evidence is found in prior research (see Ke, 2008a, 2008b; McDonald & Hannafin, 2003), empirical research is needed in this regard in the hope to better blend education games into class activity design.

From the review of the recent literature, the dominating purpose of education games is to rehearse or to review the taught materials, as Appendix A suggests. A drill and practice type of game may be a popular emerging trend in education games (Cameron & Dwyer, 2005; Ke, 2008a, 2008b; Paul, Messina, & Hollis, 2006; Yu, Chang, Liu, & Chan, 2002). Perhaps this trend may well be extended to stress a meaningful context, where knowledge, skills, and dispositions are acquired from a social-cultural perspective, as Egenfeldt-Nielsen (2007) suggests.

The Hawthorne effect as related to educational game design needs further discussion. Rosas et al. (2003) purposely design an internal control group, participants of which were informed of the study but did not receive the treatment as the experimental group does. This study confirms the existence of the Hawthorn effect in GBL studies. Researchers may need to re-examine GBL studies that suggest a non-significant difference in learning achievement (e.g., McDonald & Hannafin, 2003) by taking into account this threat to external validity.

As discussed earlier in the paper, prior research does not distinguish much difference between and among the three forms of multimedia learning objects: computer (video) games, computer simulations, and computer simulation games. As mentioned earlier in this paper (see O'Neil, Wainess, & Baker, 2005; Sauvé, Renaud, Kaufman, and Marquis, 2007), games differ from simulations in several ways. Simulation games are likely to take the hybrid form of both. Future research may examine the difference among these potential learning genres in light of learning gains attainable by each approach.

Gender differences are evidenced in young learners (e.g., Gros, 2007; Hayes, 2008). Gender differences mediate the preference to types of games. Young males tend to favor ludic aspects (relating to or characterized by play) or engagement with the logic and rules-based structure of a game; young females' selection is in favor of those games with a focus on narratology, or exceptionally powerful, possibly unique storytelling powers enabled by current multimedia systems (Inal & Cagiltay, 2007). According to the two Turkish researchers, boys (7-9 years old) are fond of rules and challenges embedded in the games, and girls (in the same age group) enjoy more of the storyline and the goal of the game. Tüzün's study (2007) also supports the use of the backstory plotted in an education game. Another difference is found in Hayes' study (2008) where boys (10-14 years old) report more access to game consoles than girls at the same age. To what degree do the current findings in gender differences hold true for adult learners?

As mentioned in the introduction of this paper, GBL pre-selects media prior to performance objectives and instructional activities. Is GBL putting the cart before the horse? Is GBL a propositional logic? The author would like to encourage readers to approach GBL with open-minded thinking and critically evaluate GBL from various vantage points as introduced below.

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Appendix A

Overview of Studies in the Primary Pool

Author	Sample Subject Academic Status	Sample Size	Game Role	Major Finding	Major Game Design feature
Ebner and Holzinger (2007)	Graduate (Austria, Germany, and Switzerland)	121	Drill-and-practice (supplemental)	Games do not show any significant effect on learning outcomes (i.e., number of correct answers). In game group, "enjoyability" factor is identified. Games show a significant effect on affective gain (i.e., high motivation→repeatedly playing). Incidental learning occurs (i.e., discovering mistakes and re-playing to correct them), a.k.a. serendipity. User-centered design—Usability matters. "No help tools should be necessary to explain how to play the game correctly" (p. 886).	Difficulty levels optional Info page where goals are described as is needed prior knowledge Red bar to monitor remaining time 6 levels with varying difficulty levels and different length of time to solve problems; ability and existing knowledge Randomized problems (motivation issue) High score list with registered nickname (different from a best of the month and a current high score lists) "Background" (relate to the game content; losing is annoying "High score and time limits" "Simplicity and clarity" "Ease of use" (adjusting game to levels of expertise) (p. 876)
Ke (2008a)	Grade 4-5 (U.S.A.)	15	Drill-and-practice (supplemental)	Games do not show any significant effect on cognitive (on a math test) or meta-cognitive (using a meta-cognitive awareness survey) gains. Games show a significant effect on affective gains (attitude change).	Situated game Role-playing a cashier Accomplish a goal Plays against computer Answer all questions to proceed Progressive levels of difficulty (harder problems later) Immediate feedback (yes/no) Use of scores (more levels competed higher scores) Game-reward mechanism: the faster the precise response, the higher scores
Ke (2008b)	Elementary (Grade 5) (U.S.A.)	487	Drill-and-practice (supplemental)	Games do not show any significant effect on cognitive gains (mathematics) when comparing game group to non-game (paper-and-pencil drills group. Games show a significant effect on affective gains (i.e., attitude change), particularly so in a cooperative learning environment (compared to individualistic and competitive ones).	Use of stories that attract learners Role playing pilots Embedded problem to be solved Use of hints Immediate feedback Difficulty levels → episodes Wanting to beat the computer Encouraging repeated learning
Kim, Park, and Baek (2009)	Middle School (Grade 9) (South Korea)	132	Integral part of school curriculum	There is a significant effect of the thinking aloud strategy on the achievement in learning and social problem solving ability. There is a significant effect of the self-recording strategy on the achievement in gaming. There is a significant effect of the modeling strategy on the achievement in learning. There is a significant effect of the social problem solving ability on the achievement in learning and that in gaming.	Strategy game→ problem solving Role-playing a wealthy merchant Familiar content Curriculum content embedded in game MMORPG Game students can relate to Two scenarios full of quests Economic scenarios: various economic activities based on concepts Battle scenario: battle for better weapons and higher levels Game selected by 3 SME's Scoring system reported: credit scores and battle scores
Papastergiou (2009)	High School (Greece)	88	Integral part of instruction (t/f and multiple choice)	Game group performs better than non-game (in WBI) group in both cognitive and affective areas. Gender is not a moderator variable in either cognitive or affective domain of learning.	Simple plot Low complexity Realistic but 3D Basic concepts embedded in game Rules Clear but challenging goals Fantasy linked to student activity Progressive difficulty levels Interactive and high learner control Uncertain outcomes Immediate/constructive feedback Matching levels with existing knowledge Evoking curiosity and motivation Gender friendly

Paul, Messina, and Hollis (2006)	Undergrad (U.S.A.)	189	Drill-and-practice (supplemental)	Games show a significant effect on cognitive gains (i.e., scoring higher on the exam than non-game players).	Games are used for review purposes, which provides a self-assessment on the learned knowledge as a meta-cognitive approach Competition used Control levels of questions Difficulty levels used Limited time for answer Give partial credit work
Rosas et al. (2003)	Elementary (Grade 1-2) (Chile)	1274	Integral part of school curriculum	Games show a significant effect on cognitive gains in (basic) reading comprehension and spelling and mathematical operations, compared to non-game (i.e., external control) group. Students in experimental schools (including both experimental group and internal control group) show more preference for education games, compared to external control group. Students who play education games pay more attention and their behavior has changed (more disciplined). (Classroom dynamics changed)	Learning is incidental (as opposed to intentional) Content is presented with increasing levels of complexity with school curriculum embedded and aligned "Antagonists and obstacles" used to present the increasing levels of difficulty Adapt learner's pace (concept of self-regulate) and existing knowledge by presenting a proper level of difficulty Interface comparable to COTS games Storyline planned
Segers and Verhoeven (2005)	Kindergarten to Grade 1 (the Netherlands)	100	Integral part of school curriculum	Education games show a significant effect (both immediate and long term) on cognitive gains (i.e., rhyming and grapheme knowledge) when compared to a non-game control group.	Activities such as singing, coloring, making a booklet, and making a postcard (in the discovery games group) Increased levels of difficulty progressively Harder games automatically become available when advanced skills shown Choose the game to play Games easy to follow Have a one-to-one correspondence between text and sound
Sung, Chang, and Lee (2008)	Kindergarten (age 4-5) (Taiwan)	60	Integral part of curriculum	Games show a significant effect on cognitive gains (e.g., categorical concepts) compared to non game computer-based instruction and the control group (without any software used)	The higher level (or stage), the more difficult Difficulty levels defined by hierarchy (i.e., superior, basis, and subordinate) of content knowledge A story line involved (e.g., packing for farm owner to be moved; that is, put things of the same categories in one box) Game activities: coloring and using telescope to locate relate objects Two trials allowed in some game Rules changed in accordance with difficulty levels Mix of process-oriented feedback and result-oriented feedback
Virvou, Katsionis, and Manos (2005)	Elementary (Age 9-10) (Greece)	90	Drill-and-practice (supplemental)	Games are effective in both cognitive and affective domains more in game-based instruction (with a virtual reality game) than non-game-based one (i.e., WBI). Academically weak students benefit most from games, then the average students. Good students benefit from both games and other computer applications. Students who play education game are seen becoming more disciplined. (Classroom dynamics changed)	Pre-determined goal While playing, practice with factual knowledge and reasoning ability Reach the goal Content presented in hierarchy → Animated agents with speech synthesizers Hint and negotiation available and random Advice tailored to learner's needs Interface attractive, comparable to COTS VR game Non violent Dialogue box as feedback channel Scoring higher than a pre-determined number to pass game Allowing guessing within reason (reasoning ability) Partial credit allowed Storyline: Adventurous game
Wang (2008)	Elementary (Grade 5) (Taiwan)	165	Drill-and-practice (supplemental as formative assessment)	Game-based formative assessment design seems more effective than two other non-game-based ones (i.e., PPT and WBI) in terms of cognitive gains. Game-based formative assessment design seems more effective than two other non-game-based ones (i.e., PPT and WBI) in terms of affective gains.	Repeat the test Correct answers are not given Query scores Asking questions encouraged Monitoring answering history All pass and then reward Ask hint strategy

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Editor's Note: This paper shows how diagnostic techniques can identify the source and nature of learning difficulties for teachers, students and instructional designers.

Model Plane Plot to Explore Effectiveness of PhET Simulation: Photoelectric-effect

Pravin Joshi and Rajendra Vadnere
India

Abstract

Photoelectric-effect' is a very important concept in understanding Introductory Quantum Mechanics courses in Physics curricula. The concept about quantum or particle nature of light is explored through this experiment. Physics Education Technology (PhET) has published a java applet which is distributed freely on the internet for benefit of physics educators and students. The authors developed a multimedia package with the PhET simulation on Photoelectric-effect at its core that explained the concept to students at 12^{th} level of schooling. The effect of the multi-media package on students is analyzed using a novel technique developed by the University of Maryland, Physics Education Research Group (PERG). This technique explores the mental model states and uses a tool of eigenvalue equations.

Keywords: mental model state, PhET simulation experiment.

Introduction

In physics, some phenomena like black body radiation, photoelectric effect cannot be explained using ideas and methods of classical mechanics. Quantum mechanics is needed to explain these phenomena. The predictions of quantum mechanics sometimes contradict our regular thinking concepts based on classical mechanics. As we know, modern physics is based on quantum mechanics so it is essential to learn the concepts of quantum theory. The introductory concepts of quantum mechanics are introduced at 10+2 level of teaching in the course of modern physics. PhET has published very useful simulation on photoelectric effect program at its website, which physics teachers can easily implement in their teaching. The authors developed a multimedia package that makes extensive use of this simulation program. Therefore, to study misconceptions of students in the new added topic and to test effectiveness of the multimedia package developed by the author using PhET simulation experiment of photoelectric effect a group 12^{th} standard, 121 students were chosen from Nashik district, Maharashtra, India. Instruction set written by authors to perform this experiment is given on PhET, in 'Teachers Ideas & Activities' under the title 'How to add Instruction set in Photoelectric Expt'. PhET is an interactive, research-based simulation of physical phenomena. Here we are going to test: how the simulations affect the students' ability to solve conceptual and quantitative problems; attitudes about learning physics; perceptions of individual learning, and how the simulations are perceived by students.

Before starting this task, a pretest of all students was conducted to test general awareness and level of understanding. Twenty-one (21) multiple choice single response (MCSR) questions were asked on the topic: photoelectric effect. Students were tested immediately after the 11^{th} standard final examination. Therefore, most of the students were not exposing to the 12^{th} standard syllabi. The pretest was based on cognitive domain[3] to find their abilities in knowledge, comprehension, application and analysis. The percentage of subset of cognitive domain in pretest is shown by pie-chart in Figure 1.

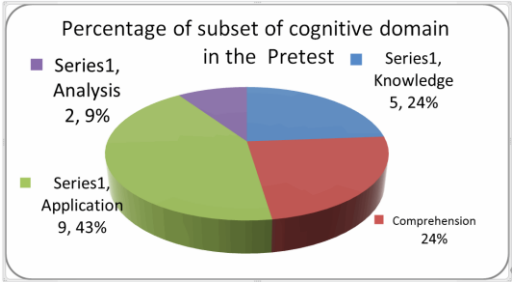


Figure 1: Percentage of subset of cognitive domain.

After the pretest, printed notes were given to all participants on the topic of photoelectric effect and they were asked them to study them in 8 days. Out of 121 students, 25 participants were selected as an experimental group (EG) by a random selection method and the remaining students were treated as a control group (CG). EG was trained on the multimedia package. They performed the simulated photoelectric experiment shown in Figure 2, as per the given instruction set. While performing the experiment, they noted readings and plotted various graphs as per the requirement. Difficulties faced by the students, were noted and solved. Instruction material supplied to the students was collected after experiment for further analysis.

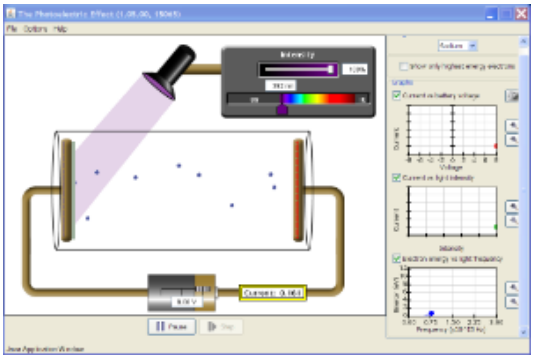


Figure 2: Photoelectric effect

Posttests for both groups (EG & CG) were conducted 15 days after the pretest. In the posttest, 30 MCSR questions were asked. Difficulty level in the posttest is slightly higher than the pretest. Questions selected in the pretest and posttest were checked by a subject-matter expert. The percentage of the cognitive domain subset in the posttest is shown by pie-chart in Figure 3.

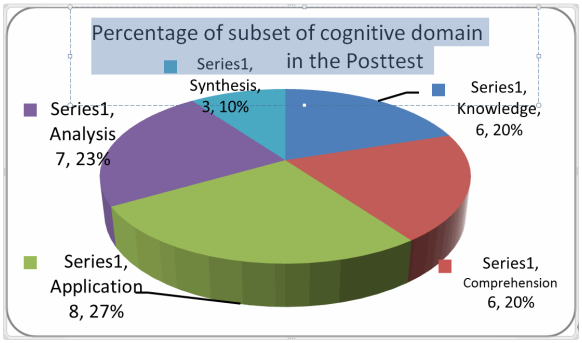


Figure 3: The techniques of analyses of pretest and posttest of CG and EG group.

The Techniques of Analysis

Even though the technique of analysis using eigenvalue equations[4,5] has been developed by the Physics Education Research Group (PERG) at the University of Maryland, the basic concepts are described here for the benefit of those who are not familiar with this technique. An understanding of basic mathematical tools like solution of density matrix, eigenvalues and eigenvectors are required to understand the techniques described here.

Problem Area

Whenever a student is presented with a problem, he or she goes through a complex web of mental activities[6, 7]. A simple model of these activities is summarized here.

The student reads the problem and tries to figure out which problem solving mechanism to apply. There may be more than one such problem solving mechanism available. In that case, a random function may trigger selection of one of the competitive mechanisms. We say that the problem has taken the student to a 'state' of mind. We may classify such states of mind in the following scheme.

Student model state

These problem solving mechanisms may involve a number of mental constructs[8, 9]. They are affected by the learning experience of the student. The term 'mental model' is used to denote such mental constructs.

The objective of education is to make the learner imitate the behavior of an expert in problem solving. If applied concept is properly fitted to a given context, this situation is said to have evoked in the student an "Expert Model" state (E state for short).

On the other hand, it is possible that the student has understood the problem, and sincerely undertakes to solve it. However, he may evoke a method of solving which may be close to the one which an expert would resort to, but not exactly the same, and thus lead to an incorrect solution to the problem. This happens when a number of concepts are similar in nature or when the student has not properly internalized a concept. In short, when the student applies a mental model which is not appropriate to the situation posed in the given problem, we say that he or she has evoked a "misconception state" (M state) for the given problem.

It is also likely that the student has not understood the problem as expected by the experts so that the student's method is far removed from the methods and practices employed by the experts and/or irrelevant to solve this problem. In such cases we say for the present communication, that the student has evoked a "Null model state" (N state) for the particular problem.

In order to analyze whether a student has developed the skill of problem solving, a number of multiple choice single response (MCSR) questions are posed to them. Each question evokes any one of the three states – namely, an *expert* state, a *misconception* state or a *null model* state. The options available to the stem are such that only one option corresponds to the expert state, while one or more choices would correspond to the misconception state or to the null model state. For a given problem, the response given by the student tells us about whether (s)he has acted like an expert or a novice or has almost not attempted it.

The analysis of the problems posed to the student gives us the probabilities of them evoking an expert model-E, a misconception model-M and a null model-N. The analysis may also give us the probability of mixed states. e.g., the E-M, M-N, and E-N or E-M-N mixed state. A similar analysis can also be performed on a class of students and we may find the probability of the class invoking an E, M or N pure model state or mixed state.

The state can be graphically represented as three-dimensional space with the three axes labeled as E, M and N. The vector drawn from origin to the point (e, m, n) on the surface of a unit sphere (i.e. radius of unity) in the first octet of the space describes the 'state' such that a student or class applies E, M and N model with probabilities e^2, m^2 and n^2 respectively (so that $e^2+m^2+n^2=1$). For example a point (0.30, 0.40, 0.87) in figure 4 denotes the situation for a student who may trigger E model with a probability $(0.3)^2$ (i.e. 9%); M model with probability $(0.4)^2$ (i.e. 16%) and N model with probability $(0.87)^2$ (i.e. 75%).

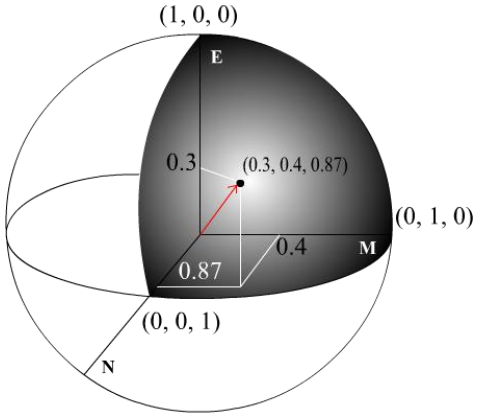


Figure 4: A student model state

Student Response Vector

Here the 'state' of a system is described by vector. A vector (e, m, n) shown in Figure 4 represents a state of a student. As discussed earlier, the student may apply a model or method (a) which we would expect an expert to employ when faced with a similar situation (E state), or (b) which is not appropriate to the given situation posed in the given problem - a "misconception state" (M state), or (c) evoked an irregular ideas then it is a "Null model state" (N state) for the particular problem.

In such a case we may consider a k^{th} student response who has been asked 'q' number of questions which are all multiple choice questions with 'r' choices for each of them. Suppose that a student answers e number of questions correctly (Expert state); answers m number of questions where the concept was not properly internalized (exhibiting Misconceptions) and answers n number of questions in a wrong manner (exhibiting Null state). Then we can say that the probability of them in N state is n/q, while the probability of finding them in E state is e/q and that for the M state is m/q. Note that q=e+m+n.

In quantum mechanics, we speak about the probability amplitude vector such that the norm of such vector is proportion to the probability of finding the system in that state.

For a single student labeled k who has been asked q questions of multiple choices, the student state vector can be constructed as

$$u_k = \begin{bmatrix} \sqrt{e/q} \\ \sqrt{m/q} \\ \sqrt{n/q} \end{bmatrix} = \frac{1}{\sqrt{q}} \begin{bmatrix} \sqrt{e} \\ \sqrt{m} \\ \sqrt{n} \end{bmatrix}$$

The k^{th} student model vector is represented with $|u_k\rangle$, where k = 1, 2, 3… $\mathcal{N}$ and the student 'density matrix' for k^{th} student are defined as:

$$D_k = |u_k\rangle\langle u_k|$$

$$D_k = \frac{1}{\sqrt{q}}\begin{bmatrix}\sqrt{e}\\ \sqrt{m}\\ \sqrt{n}\end{bmatrix}\frac{1}{\sqrt{q}}\begin{bmatrix}\sqrt{e} & \sqrt{m} & \sqrt{n}\end{bmatrix}$$

$$D_k = \frac{1}{q}\begin{bmatrix} e & \sqrt{em} & \sqrt{en} \\ \sqrt{me} & m & \sqrt{mn} \\ \sqrt{ne} & \sqrt{nm} & n \end{bmatrix} \qquad Eq(1)$$

Class Density Matrix

We can construct class density matrix *D,* by taking average of student density matrix for the whole class comprising of $\mathcal{N}$ students as

$$D = (1/\mathcal{N}) \sum_{k=1}^{N} D_k \qquad Eq(2)$$

The Student Model Density Matrix D_k retains the structural information on individual student responses with respect to different physical models. Similarly, the class model density matrix stores important structural information about the class of students. Three types of samples of Class Model Density Matrix are:

Consistent one-model:

When almost all the student in the class employ and exhibit same physical model (not necessary the correct one) and they are always consistent about it such situation is referred to as Consistent one-model. This situation is characterized by the class density matrix of the form

$$D = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

Consistent multi-model:

Students in the class have several different physical models but each student has only one physical model and is consistent about it. Suppose, in a class of 100 students 50 students respond to questions exhibiting E state for all the questions asked, while 30 students respond with all questions in M state and 20 students answer all questions in a manner characteristic of N state. In such a case, the Class Model Density Matrix can be calculated by using the formulations given in the preceding section as

$$D = \frac{1}{100}\begin{bmatrix} 50 & 0 & 0 \\ 0 & 30 & 0 \\ 0 & 0 & 20 \end{bmatrix} = \begin{bmatrix} 0.5 & 0 & 0 \\ 0 & 0.3 & 0 \\ 0 & 0 & 0.2 \end{bmatrix}$$

The diagonal elements indicate the probability of finding a student with "pure" (i.e., consistent) state. In this case 0.5, 0.3 and 0.2 are weight-age for E, M and N states respectively. It may be noted that the off diagonal elements are zero. The Consistent multi model situation is characterized by zero off-diagonal elements.

Inconsistent multi-model

This is the most pragmatic situation. The students in the class have different physical models and they are not consistent in using these models. A typical class Density Matrix is of the form

$$D = \begin{bmatrix} 0.5 & 0.2 & 0.1 \\ 0.2 & 0.3 & 0.1 \\ 0.1 & 0.1 & 0.2 \end{bmatrix}$$

In this matrix, diagonal elements indicate probability of students in the 'pure' model i.e. 0.5, 0.3 and 0.2 correspondent to E, M and N states respectively. The off-diagonal elements indicate 'mixing states' (i.e., students are not consistent about the states E, M or N) of the students using the different physical models in generating their responses. Therefore further analysis is required to see how exactly the information of the individual students model states can be extracted from the class Density Matrix (D) and what the Eigenvalues and Eigenvectors of D represent.

Eigenvalue Equations

Of particular importance is a transformation which does not change the direction of the vector. In such cases the transformed vector gets multiplied by a scaling factor λ, where λ is a real number. For example a transformation matrix A operated on vector v gives same vector with multiplication of some scalar quantity say λ this can be is written as:

$$Av = \lambda v$$

This equation is called as an eigenvalue equation. The solution to this equation would be a set of vectors v_r which are called eigenvectors and a set of numbers (λ_r) called eigenvalues. In the present communication, the cases described have the real numbers as eigenvalues.

Eigenvalues and Eigenvectors of Density Matrix:

The class model density matrix (using eq-1 and 2) for a class of $\mathcal{N}$ students is:

$$D = (1/\mathcal{N}) \sum_{k=1}^{N} D_k = (1/\mathcal{N}) \sum_{k=1}^{N} |u_k\rangle\langle u_k|$$

Multiplying by vector $|v_\mu\rangle$ on both side

$$D|v_\mu\rangle = (1/\mathcal{N}) \sum_{k=1}^{N} |u_k\rangle\langle u_k||v_\mu\rangle ...Eq(3)$$

Let us denote the eigenvectors of D by $[v_1, v_2 ... v_\mu ... v_w]$. Here w is the number of model states considered for analysis and each element of $[v_\mu]$ is a column vector with corresponding eigenvalues are σ_μ^2 $(where \mu = 1, \quad 2, \quad ... \quad w)$.

Eigenvalue equation $Av = \lambda v$ can be replaced by

$$D|v_\mu\rangle = \sigma_\mu^2 |v_\mu\rangle \qquad Eq(4)$$

Where $A = D$ and $\lambda = \sigma^2$

Agreement Factor

Now let us define $a_{\mu k}$ is the agreement between the k^{th} student model vector and μ^{th} eigenvector.

$$a_{\mu k} = \langle u_k | v_\mu \rangle = \langle v_\mu | u_k \rangle$$

Equating Eq. (3) and (4)

$$D|v_\mu\rangle = (1/N)\sum_{k=1}^{N} |u_k\rangle\langle u_k \| v_\mu\rangle = \sigma_\mu^2 |v_\mu\rangle$$

Then can be written as:

$$D|v_\mu\rangle = (1/N)\sum_{k=1}^{N} a_{\mu k}|u_k\rangle = \sigma_\mu^2 |v_\mu\rangle$$

$$|v_\mu\rangle = (1/N)\frac{1}{\sigma_\mu^2}\sum_{k=1}^{N} a_{\mu k}|u_k\rangle \qquad Eq(5)$$

Thus from *Eq*. (5), an eigenvector v_μ of *D* is a weighted average of all individual student model vectors u_k with weight equal to the agreements $a_{\mu k}$ between the eigenvector v_μ and the single student model vector u_k . Therefore the class model states represented by these eigenvectors are the set of $[v_1 \ldots v_w]$ states that most resemble the salient features of all the individual student model vectors. From *Eq. (5),* it is also obvious that the structure of $|v_\mu\rangle$ will have more contribution from students model vectors $|u_k\rangle$ that are closer to $|v_\mu\rangle$.

Therefore if there exist a group of $|u_k\rangle$'s that are very similar to each other but different from the rest this group of $|u_k\rangle$'s will have a significant effect to make one of the eigenvectors ($|v_\mu\rangle$'s) similar to them.

If we left multiply by $\langle v_\mu|$ to *Eq*. (5) (recall that $\langle v_\mu | v_\mu \rangle = 1$ and $a_{\mu k} = \langle u_k | v_\mu \rangle = \langle v_\mu | u_k \rangle$)

$$\langle v_\mu | v_\mu \rangle = (1/N)\frac{1}{\sigma_\mu^2}\sum_{k=1}^{N} a_{\mu k} \cdot \langle v_\mu | u_k \rangle$$

$$= (1/N)\frac{1}{\sigma_\mu^2}\sum_{k=1}^{N} a_{\mu k}^2 = 1$$

$$\text{Thus} \quad \sigma_\mu^2 = (1/N)\sum_{k=1}^{N} a_{\mu k}^2 \qquad Eq(6)$$

This result indicates that the μ^{th} eigenvalue (σ_μ^2) is the average of the square of the agreements between the μ^{th} eigenvector v_μ and the individual student model vector u_k .

It can be concluded from Eq. (6) that the eigenvalue is affected by both the similarity of the individual student model vector u_k and the number of students with similar model vectors. In

order to have a large eigenvalue required to have not only large $a_{\mu k}^2$, but also a good number of them, which implies that more students in the class have more similar student model vectors. That is, the students in the class behave more similarly to each other (the consistency between students is high).

As we define earlier $a_{\mu k}$ is the agreement between the k^{th} student model vector and μ^{th} eigenvector. This agreement factor gives the degree of agreement for individual student with the class model states. Similarly it is necessary to find how the class model states itself is shifted from the physical model. Since the class model states represent the probability amplitude, the probability based agreement between a physical model and a student class model state is defined as the square of the scalar product between the two model vectors.

$$v_{\mu\eta}^2 = \left\langle v_\mu \middle| e_\eta \right\rangle^2 \qquad Eq(7)$$

Where e_η is the base vector (e.g., (0, 1) or (1, 0) for a two-model analysis) representing the η^{th} physical model. Thus, each component of eigenvector $v_{\mu\eta}$ shows the agreement between the class model states and the physical models.

Example of inconsistence multi-model Density Matrix and Class model state vectors

$$D = \begin{bmatrix} 0.5 & 0.2 & 0.1 \\ 0.2 & 0.3 & 0.1 \\ 0.1 & 0.1 & 0.2 \end{bmatrix}$$

The eigenvectors and eigenvalues of D are found by using SciLab10 is:

$$v = \begin{bmatrix} 0.81 & -0.58 & 0.14 \\ 0.52 & 0.58 & -0.63 \\ 0.29 & 0.58 & 0.77 \end{bmatrix} = \begin{bmatrix} v_1 & v_2 & v_3 \end{bmatrix}$$

$$\sigma^2 = \begin{bmatrix} 0.66 & 0 & 0 \\ 0 & 0.20 & 0 \\ 0 & 0 & 0.14 \end{bmatrix} = \begin{bmatrix} \sigma_1^2 & 0 & 0 \\ 0 & \sigma_2^2 & 0 \\ 0 & 0 & \sigma_3^2 \end{bmatrix}$$

Which is satisfy the equation $Av = \lambda v$

The eigenvectors for student model states can be represented as showing in Figure 5. The model states can be graphically represented as three-dimensional space with the three axes labeled as E, M and N. The eigenvalues are represented as points on the correspondent eigenvectors.

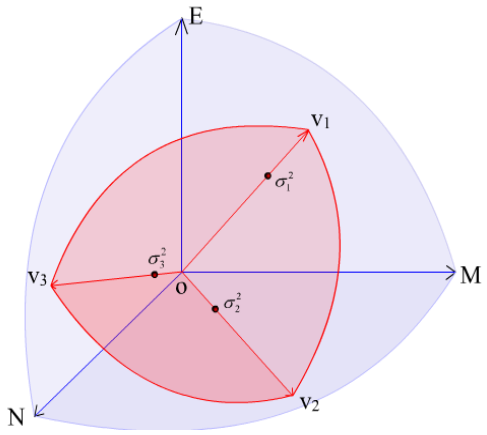


Figure 5: Student class model state vectors

Model Plane Plot

As we know, the class model vectors are the weighted average of all the individual student model vectors. As a result, a class model states contains all the signature information from all the individual student model states. The eigenvalues can be used as a measure to tell if the students are similar or different from each other. A large dominant eigenvalues indicates that many students are similar to each other and the single student model vectors for different students are similar. On the other hand, if students are all different from one another, the individual student model vectors will have different structures. As a result, it is difficult to find a vector that agrees well with a large number of different single student model vectors. In such cases, there will be no dominant eigenvalues. Therefore the eigenvalues can be used as a measure to tell if the students are similar or different from one another. In many cases, it is observed that students often have model states structured with one dominant component of eigenvalue.

As per the eq.7 each component of eigenvector $v_{\mu\eta}$ shows the agreement between the class model states and the physical models. Therefore major part of the student model states will decide the product of dominant component of eigenvalue σ_μ^2 and square of the corresponding eigenvector v_μ^2 of the class model state is shown in Figure 6 with coordinates ($\sigma_\mu^2 v_{1\mu}^2$, $\sigma_\mu^2 v_{2\mu}^2$).

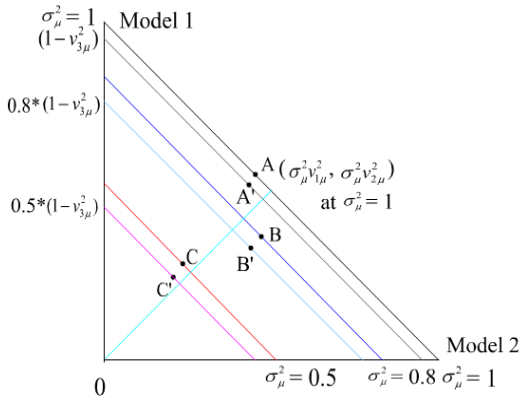


Figure 6: Sample student model plot

Here we considered only two model states because we are interested in finding students model state in correct one and misconception (i.e. model-1 and model-2). The '*model plane plot'* by using two physical models as an axis is shown in Figure 6.

In this plot, though we are not considering null model states then also it affects on student model plot and the points A, B, C are shifted to the points A', B', C'. Explain of location of these points and their shifting are here by considering various cases.

Location of points with zero null components:

Case-1: for the extreme case of a 100% model concentration of one of the state, student model state will be either (1, 0) or (1, 0). In this case eigenvalue is unity (σ_μ^2=1); it indicates that all students in the class have the same responses. Therefore in this case class response vector is same as the student response vector.

Case-2: If there exits mixed states between two models and all students in the class have the same responses then students model state varies on a line (1, 0) and (1, 0), which is the upper boundary of the model region. This line is called an ideal model line. No model points can exits above this line. Suppose point A is on upper boundary line then its horizontal and vertical component is $(v_{2\mu}^2, v_{1\mu}^2)$ where σ_μ^2=1.

Case-3: If there exist a dominant state with an eigenvalue is larger than 0.8 then this state is often enough to represent the hole class. In such cases, usually only the dominant state is plotted and it is considered as the '*primary model state'* (explained in next section). In that case student model state is below the ideal model line shown by point B on a line (0.8, 0) and (0, 0.8).

Case-4: Consider student model with smaller eigenvalue. It represents insignificant model states (less popular) and in that case student model point is shifted towards origin shown in figure 7 by point C with σ_μ^2=0.5.

In above four cases we considered zero null components therefore points A, B and C lying on a line joining to the points (0, σ_μ^2) and (σ_μ^2, 0) with corresponding eigenvalues: 1, 0.8, 0.5 as shown in figure 6.

Location of points with null components:

Case-5: Now if null component is not zero then the model points A, B and C are shifted to the points A', B' and C' respectively by the distance $(1-v_{3\mu}^2)$ towards the origin. The points A', B' and C' are lies on a line joining to the points (0, $\sigma_\mu^2(1-v_{3\mu}^2)$) and ($\sigma_\mu^2(1-v_{3\mu}^2)$, 0) with corresponding eigenvalues: 1, 0.8 and 0.5. If null component is zero $(v_{3\mu}^2 = 0)$ then line is shifted to the points joining (0, σ_μ^2) and (σ_μ^2, 0) as discussed in above cases.

Model regions on model plot

The model plot is mainly divided in two regions named by *primary region* and *secondary region*. The area above the line (0.4, 0) and (0, 0.4) is treated as a *primary region* as shown in figure-7. In general model plot with dominant eigenvalue (so that this state is often enough to represent the hole class), is comes under *primary region*. The area below *primary region* is called as *secondary region* where the eigenvalue is not a dominant factor.

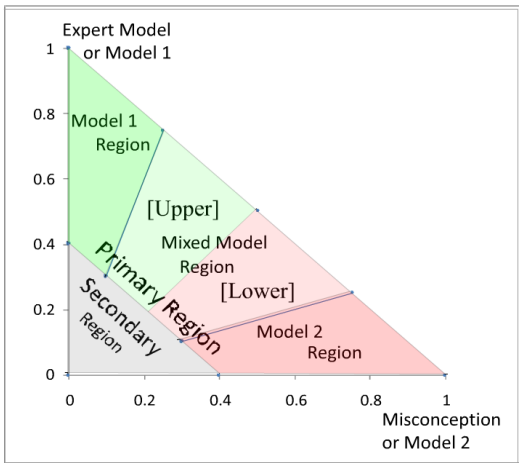


Figure 7: Model regions on model plot

The primary region is divided into three partitioned, the 'model 1 region', the 'model-2 region' and the 'mixed model region'. The 'Model 1 region' is dominant of expert model, similarly the 'model 2 region' is dominant of strong misconception and middle region between these two models is 'mixed model region'.

If student model states are in 'model 1 region' imply good understanding of given concept, while if student model states are in 'model 2 region' indicate a strong misconception.

Model points in the 'mixed region' can represent a mixed model state, where no physical model is in dominant and the individual students are inconsistent in using different physical models. For further analysis we may partitioned this region into upper and lower mixed region. 'Upper-mixed region' is near to expert model (or model-1) so that the students in this region are more expert as compare to students in the 'lower-mixed region'.

The 'secondary model region' represents model states with small eigenvalues and therefore they are usually considered secondary with much smaller effect on the overall performance.

Analysis using Model Plane Plot

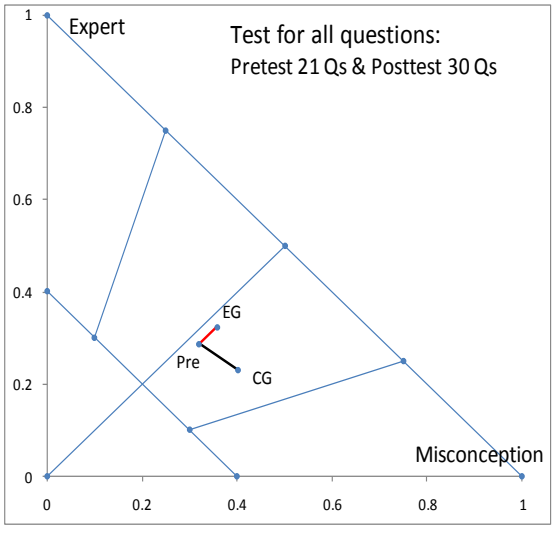
To draw a model plane plot, it is necessary to find class density matrix, eigenvalues and eigenvectors of various tests. To plot the graph we considered only dominant eigenvalue and corresponding eigenvector with first two components (i.e. model-1 and model-2). The plotted point ($\sigma_\mu^2 v_{1\mu}^2, \sigma_\mu^2 v_{2\mu}^2$) is shown in figure 5. Class density matrix, eigenvalues and eigenvectors of each test with various contexts is given here. Dominant eigenvalue and first two components corresponding eigenvector is shown by bold letter. Various points are drawn on the graph and it is connected by a line. This change shows the corresponding class model states after some course of action. The graph of various contexts for pretest and posttest are given here and there Conclusions is noted.

Model Plane Plot

Table: Model Plane Plot for all questions.

Pretest: 121 students	**Posttest: EG-25 students**	**Posttest: CG-73 students**
21 Questions	**30 Questions.**	
$D=$ 0.30 0.30 0.31 0.30 0.33 0.33 0.31 0.33 0.37	$D=$ 0.33 0.34 0.29 0.34 0.37 0.31 0.29 0.31 0.30	$D=$ 0.24 0.30 0.28 0.30 0.41 0.37 0.28 0.37 0.36
$\sigma^2 =$ 0.96 0 0 0. 0.01 0 0. 0. 0.02	0.96 0 0 0. 0.01 0 0. 0. 0.03 $\sigma^2 =$	0.98 0 0 0. 0.01 0 0. 0. 0.01 $\sigma^2 =$
$v =$ - 0.55 - 0.61 - 0.57 - 0.58 0.77 - 0.27 - 0.61 - 0.18 0.77	- 0.58 - 0.70 - 0.42 - 0.61 0.71 - 0.34 - 0.54 - 0.06 0.84 $v =$	- 0.48 - 0.84 - 0.22 - 0.64 0.52 - 0.57 - 0.60 0.13 0.79 $v =$
Point ($\sigma_\mu^2 v_{1\mu}^2$, $\sigma_\mu^2 v_{2\mu}^2$)		

All questions	Pre	CG	EG
Expert model	0.29	0.23	0.32
Misconception	0.32	0.4	0.36



Conclusion:

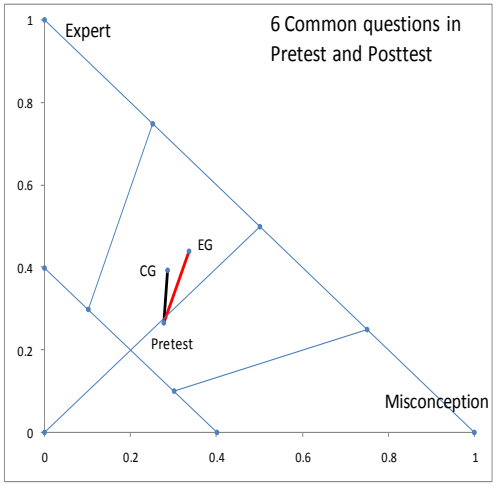
All three plots (i.e. Pretest, CG and EG) of student class model states are in the lower-mixed region, indicates that course is less effective. So it needed improvement in notes and instruction set of the simulation experiment.

Table: Model Plane Plot for six common questions.

Pretest: 121 students	**Posttest: EG-25 students**	**Posttest: CG-73 students**
Common 6 Questions		
$D=$ 0.31 0.26 0.26 0.26 0.32 0.26 0.26 0.26 0.37	$D=$ 0.46 0.38 0.2 0.38 0.35 0.19 0.2 0.19 0.19	$D=$ 0.44 0.32 0.22 0.32 0.32 0.21 0.22 0.21 0.24
$\sigma^2=$ 0.85 0 0 0 0.05 0 0 0 0.09	0.90 0 0 0. 0.02 0 0. 0. 0.08 $\sigma^2=$	0.85 0 0 0. 0.10 0 0. 0. 0.05 $\sigma^2=$
$v=$ 0.56 0.74 - 0.37 0.57 - 0.67 - 0.48 0.60 - 0.06 0.79	- 0.70 - 0.60 - 0.39 - 0.61 0.78 - 0.09 - 0.36 - 0.17 0.91 $v=$	- 0.68 - 0.57 0.46 - 0.58 0.04 - 0.81 - 0.44 0.82 0.36 $v=$

Point $(\sigma_\mu^2 v_{1\mu}^2,\ \sigma_\mu^2 v_{2\mu}^2)$

6 common questions	Pre	CG	EG
Expert model	0.27	0.39	0.44
Misconception	0.28	0.29	0.33



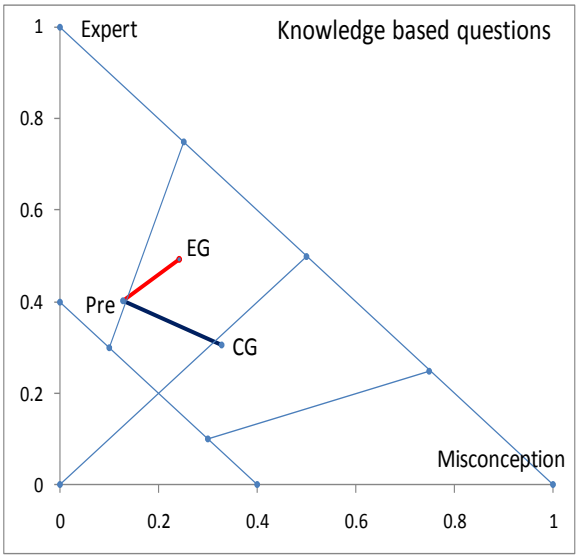
Conclusion:

Student class model state of pretest is in lower mixed region and posttest of both groups (EG and CG) are shifted in upper-mixed region shows satisfactory result of notes and instruction set.

Table: Model Plane Plot for knowledge based questions.

Pretest: 121 students	**Posttest: EG-25 students**	**Posttest: CG-73 students**
5 Questions	6 Questions.	
$D=$ 0.46 0.21 0.27 0.21 0.19 0.16 0.27 0.16 0.36	$D=$ 0.53 0.32 0.17 0.32 0.29 0.14 0.17 0.14 0.19	$D=$ 0.36 0.3 0.22 0.30 0.36 0.25 0.22 0.25 0.28
$\sigma^2=$ 0.80 0 0 0. 0.13 0 0. 0. 0.06	$\sigma^2=$ 0.83 0 0 0. 0.06 0 0. 0. 0.12	$\sigma^2=$ 0.85 0 0 0. 0.10 0 0. 0. 0.05
$v=$ 0.71 - 0.56 0.42 0.40 - 0.17 - 0.90 0.58 0.81 0.10	$v=$ - 0.77 - 0.46 - 0.43 - 0.54 0.83 0.08 - 0.32 - 0.30 0.89	$v=$ - 0.60 - 0.64 0.48 - 0.62 - 0.01 -0.78 - 0.50 0.77 0.39
Point $(\sigma_\mu^2 v_{1\mu}^2,\ \sigma_\mu^2 v_{2\mu}^2)$		

Knowledge based questions	Pre	CG	EG
Expert model	0.404	0.306	0.492
Misconception	0.126	0.327	0.242



Conclusion:

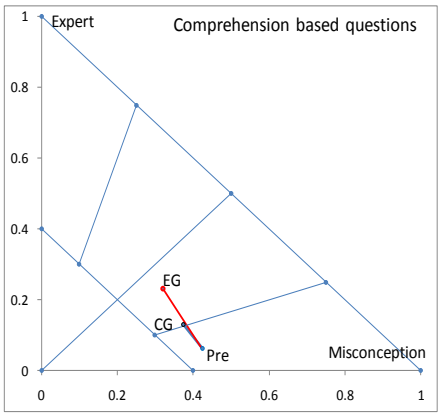
In knowledge based questions student class model state of pretest is in expert model region shows good understanding level of students.

Student class model state of CG is shifted in lower mixed region and EG is shifted in upper mixed region shows adverse effect of the notes and instruction set of the simulation experiment. So more improvement is needed in notes and instruction set. Though by considering higher difficult level of the posttest, there is improvement in EG as compare to CG but the expected position of EG should be in expert model state.

Model Plane Plot for Comprehension based questions in pretest and posttest

Pretest: 121 students	Posttest: EG-25 students	Posttest: CG-73 students
5 Questions	6 Questions.	
$D=$ 0.13 0.14 0.14 0.14 0.46 0.36 0.14 0.36 0.40	$D=$ 0.29 0.26 0.23 0.26 0.35 0.30 0.23 0.30 0.36	$D=$ 0.20 0.20 0.20 0.20 0.41 0.35 0.20 0.35 0.38
$\sigma^2=$ 0.85 0 0 0. 0.07 0 0. 0. 0.06	0.86 0 0 0. 0.09 0 0. 0. 0.04 $\sigma^2=$	0.86 0 0 0. 0.08 0 0. 0. 0.04 $\sigma^2=$
$v=$ 0.27 0.77 - 0.58 0.71 - 0.56 - 0.42 0.54 - 0.30 0.69	$v=$ - 0.52 - 0.75 0.42 - 0.61 - 0.02 -0.79 - 0.60 - 0.66 0.44	$v=$ 0.39 0.91 - 0.14 0.66 - 0.38 - 0.64 0.64 - 0.16 0.75
Point $(\sigma_\mu^2 v_{1\mu}^2,\ \sigma_\mu^2 v_{2\mu}^2)$		

Comprehension based questions	Pre	CG	EG
Expert model	0.062	0.131	0.232
Misconception	0.425	0.375	0.320



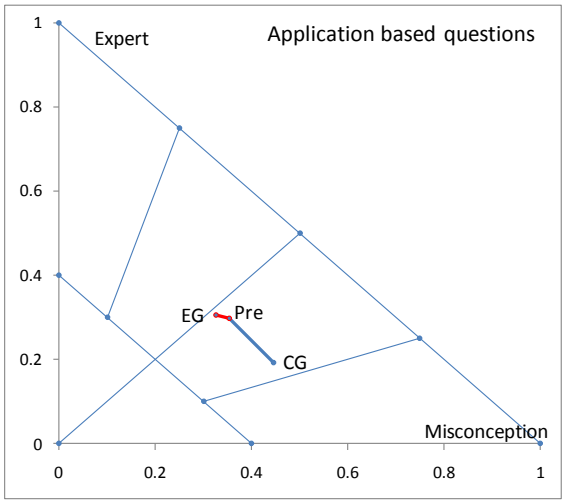
Conclusion:

Student class model state of pretest is in misconception region and CG is shifted on the boundary of misconception and lower mixed region while EG is shifted in lower mixed region shows effective change in students after treatment. More effort is required to shift EG and CG towards expert model in comprehension based questions.

Table: Model Plane Plot for Application based questions.

Pretest: 121 students	Posttest: EG-25 students	Posttest: CG-73 students
9 Questions	8 Questions.	
$D=$ 0.32 0.31 0.27 0.31 0.38 0.29 0.27 0.29 0.30	$D=$ 0.35 0.31 0.20 0.31 0.37 0.20 0.20 0.20 0.29	$D=$ 0.22 0.28 0.23 0.28 0.47 0.33 0.23 0.33 0.30
$\sigma^2 =$ 0.92 0 0 0. 0.05 0 0. 0. 0.03	 0.82 0 0 0. 0.05 0 0. 0. 0.14 $\sigma^2 =$	 0.91 0 0 0. 0.03 0 0. 0. 0.05 $\sigma^2 =$
$v =$ 0.57 - 0.45 0.68 0.62 - 0.31 - 0.72 0.54 - 0.83 0.10	$v =$ - 0.61 - 0.73 -0.29 - 0.63 0.68 -0.37 - 0.47 0.04 0.88	$v =$ - 0.46 - 0.79 0.40 - 0.70 0.04 -0.71 - 0.55 0.61 0.57
Point ($\sigma_\mu^2 v_{1\mu}^2$, $\sigma_\mu^2 v_{2\mu}^2$)		

Application based questions	Pre	CG	EG
Expert model	0.299	0.193	0.305
Misconception	0.353	0.446	0.325



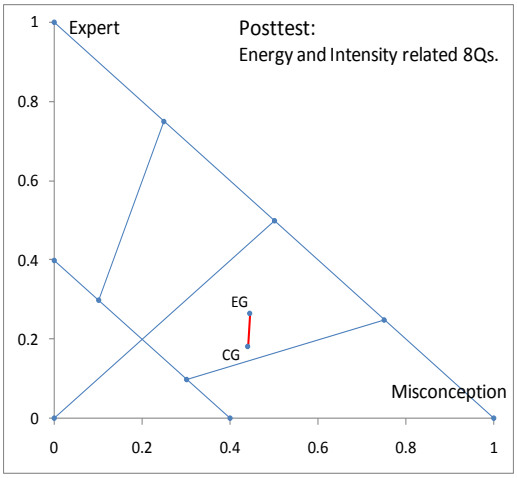
Conclusion:

This model plane plot is similar to plane plot of 9.1, so to progress in application based questions needed more improvement in notes and instruction set of the simulation experiment.

Table: Plot for Energy-Intensity related 8 questions in posttest.

Posttest: EG-25 students	**Posttest: CG-73 students**
8 Questions.	
$D=$ 0.31 0.33 0.19 0.33 0.46 0.28 0.19 0.28 0.23	$D=$ 0.22 0.27 0.22 0.27 0.46 0.35 0.22 0.35 0.33
0.89 0 0 0. 0.08 0 0. 0. 0.03 $\sigma^2 =$	0.92 0 0 0. 0.05 0 0. 0. 0.04 $\sigma^2 =$
$v =$ - 0.54 - 0.70 0.45 - 0.70 0.09 - 0.70 - 0.45 0.70 0.55	$v =$ - 0.44 - 0.85 0.27 - 0.69 0.13 - 0.71 - 0.57 0.51 0.64
Point ($\sigma_\mu^2 v_{1\mu}^2$, $\sigma_\mu^2 v_{2\mu}^2$)	

Energy-Intensity related questions	CG	EG
Expert model	0.1818	0.2660
Misconception	0.4399	0.4452



Conclusion:

Both CG and EG plots are in lower-mixed model region, required more improvements in instruction set of simulation experiment w.r.t. notes.

Summary:

Though difficulty level of the posttest is little bit higher than the pretest then, after using simulation experiment, it is expected that EG should be shifted in the expert model region. Therefore improvement in the instruction set of the simulation experiment is needed and repetition of the experiment is expected until the target is reached.

From various 2D plot it is concluded that using *PhET* simulation of photoelectric effect, students performance are better in subset of cognitive domains like gain in knowledge comprehension ability and application areas as compare to notes. Also it is observed that ability to solve conceptual and quantitative problems are increased.

Student model states are mostly are in the '*mixed model region'* in pretest as well as in posttest. Thus drastic change in student model state towards expert model is not observed after posttest. One of the reasons may be that student exploring first time to the new syllabus or student may require more and more practice of PhET simulation experiments.

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Editor's Note: This paper explores the structure of articles for one specific discipline. It is a search for standards and best practices to be taught and adopted by the current generation of teachers and students.

An Exploration of a Genre Set: Research Article Abstracts and Introductions in Electrical Engineering-Power

Massoud Rahimpour, Elham Zakeri , Ali Zakeri
Australia and Iran

Abstract

Academic writing is an inevitable part of almost all postgraduate and graduate students' academic life. Electrical Engineering-power (EAP) teachers and researchers try to facilitate this task by conducting different kinds of studies investigating different genres in and across disciplines. Genre sets are a part of the entire genre group in which a particular individual engages during his/her study. The main purpose of this paper is to focus on genre sets discussed by Devitt (1991). The set chosen for this paper is academic articles in Electrical Engineering–power field. This paper is thus an attempt to analyze articles from the above mentioned field of study to see whether there are generalizations and consistencies in the moves teachable to students of this field who encounter these genre sets in years of their study and later career. The generic structure of the abstracts and introductions of six articles from six outstanding journals in electrical engineering-power field were chosen randomly and investigated to see whether all followed the same guidelines. They were analyzed according to the models introduced by Bhatia (1993) and Swales (1990). The results indicated that there were commonalities in moves with some variations in the steps covered. The findings have pedagogic implications for EAP instruction and material development.

Keywords: research articles, abstracts, introductions, genre.

Introduction

Working in Electrical Engineering-power (EAP) is no easy job. One of the ways which might pave the way for EAP teachers in different academic fields might be getting help from the papers investigating generic moves in different fields. These papers show which generic moves are present in different fields and which are absent and the steps to realize these moves will also be manifest. There are many researchers working on this area trying to help EAP which really is in need of help.

But what is genre? To define it, we would like to cite Fairclough (2003) who believes that genres are different ways of interacting discoursally. This is one way of looking at genre. Charaudeau & Maingueneau (2002) also determine four different analytic conceptualizations of genre. They say a text's genre may be determined by its linguistic function, formal traits, textual organization and relations of communicative situation to formal and organizational traits of the text.

There are different studies investigating different parts of research articles (RA) to see whether they are similar or different across disciplines and also throughout one discipline only. These studies pay attention to the overall organization of the papers, its moves and the steps prevalent in the moves across different genres.

Samraj(2005) and Ping & et al (2010) conducted almost the same studies to analyze abstracts and introductions in two disciplines and the conclusion was that disciplinary variation in academic writing is not just manifested in generic structure but also in the relationship among genres. Habibi (2008) also conducted a similar study for psycholinguistic and sociolinguistic RAs and at the end suggested and called for a more flexible organization of the research articles. In his own words, he seeks an organization which is pattern-seeking rather than pattern-imposing.

The moves in the abstracts of scientific and nature journals were studied by Oneplee (2008) in his thesis. He came up with five moves which were background information, purpose, method, result and conclusion. He believes that the studies like this can help pave the way for native and nonnative writers in academic fields.

Arulandu (2006) also investigated the introductions of thesis and PhD dissertations written by postgraduate students to come up with some patterns and to help the academic writers to organize their dissertations more academically and consistently.

Research article introductions written by Thai academic writers were analyzed by Jogthong (2001). For the analysis he also used the model (Swales, 1990) which was employed in the current paper. The results show that the pattern of studied RAIs supports the general framework presented by Swales but the specific steps in the introductions are less consistent with the model.

The main purpose of this paper is to focus on genre sets discussed by Devitt (1991).Genre sets are a part of the entire genre group in which a particular individual engages during his/her study. The set chosen for this paper is academic articles in Electrical Engineering –power field. This paper is thus an attempt to analyze articles from the above mentioned field of study to see whether there are generalizations and consistencies in the moves teachable to students of this field who encounter these genre sets in years of their study and later career.

As stated in Samraj (2005), abstracts and introduction parts are two genres which have been in the centre of attention and this paper investigates these two to come up with commonalities.

The above review of the current literature generated the following research question and research hypothesis:

Research Question: Is it possible to find a teachable pattern in RA organization in a specific field of study?

Research Hypothesis: It is possible to find a teachable pattern in RA organization by studying prominent examples in that field.

Data and Method

Six articles were chosen randomly from six different journals in the field of Electrical Engineering. The key word to choose the articles was “Power System Stabilizers” or PSS. This topic is one of the commonest topics in this field which attracts much attention among researchers of power engineering. That is why the researchers decided to choose it for this paper. The names of the articles and journals and other details are provided in Table 1. Also, the abstracts and introductions which were analyzed for this paper are listed in the Appendix.

To analyze the articles, two models were used: Bhatia (1993) for abstracts and Swales (1990) for introductions. These are the models frequently used in the other papers to investigate these two genres. The researchers adopted the idea from Samraj (2005).

Bhatia suggests that there are usually four moves in abstracts which are purpose, methods, results and conclusions. It is discussed that these moves correspond to the whole structure of the research article which includes: introduction, methods, results and discussion.

Swales model for introductions consists of three moves which are: Establishing a territory, establishing a niche and occupying the niche. These four moves can be manifested in different steps which are shown in Table 2:

Table 1
List of the articles studied in this paper

Title of the Article	Authors	Name of the Journal	Year of Publication
1. Robust Design of Decentralized Power System Stabilizers using Meta-heuristic Optimization Techniques for Multimachine Systems	Jeevanandham,A., Thanushkodi.K.G.	Serbian Journal of Electrical Engineering	2009
2. An Improved Simple adaptive Control Applied to Power system Stabilizer	Shaoru Zhang, Fang Lin Luo.	IEEE Transactions on Power Electronics	2009
3. Robust power system stabilizer design under multi-operating conditions using differential evolution	Z.Wng, C.Y.Chung, K.P.Wong, C.T.Tse	IET Generation, Transmission & Distribution	2008
4. The Effective Role of AVR and PSS in Power Systems: Frequency Response Analysis	Graham J.W.Dudgeon, William E.Leithead, John O'Reilly, James R.McDonald	IEEE Transactions On Power Systems	2007
5. Fuzzy Logic Controller as a Power System Stabilizer	Corcau,J.I., Stoenescu,E.	International Journal Of Circuits,Systems and Signal Processing	2007
6. Theory and Method for Selection of Power System Stabilizer Location	Zhout,E.Z., Malik,O.P., Hope,G.S.	IEEE Transactions On Energy Conversion	1991

In the case of the first article (2009), three moves are present in the abstract part, i.e. purpose, methods and results. There are not any conclusions included in the abstract part. In the introduction part of the same article claiming centrality and topic generalizations are present to establish the territory. Then some explanations are given to further help the reader understand what might come up in the rest of the paper. This is the only move present in the introduction part and it seems to the researcher that this is the case discussed by Anthony (1999). He indicated that there are explanations about key terms in engineering fields .This is what we have in this article. Actually the present study is outlined in other parts with other headings.

In the second article (2009) in the abstract part three moves are present: the articles, the methods and the results. The conclusion seems to be absent again. In the introduction part of the same article the author starts with claiming centrality and topic generalization. Then there in a comparison between the model used in this article and the ones before to show that the paper in continuing a tradition and here the gap is present. At the end, the present study, purpose and the principle findings are announced. The conclusion is that all the three moves for the introduction are present in this article.

In the abstract part of the third article (2008) again three moves are recognized which are: purpose, method and results. Following the abstract, the introduction starts with generalizations and claiming centrality. The authors then claim that they are continuing a tradition and the gap is indicated. Finally there is a talk of the present study which is representative of filling the gap. In this article we also have the RA structure at the end.

The abstract of the fourth article (2007) is comprised of the purpose, method and results following the seemingly the same tradition in the articles of this field. The introduction starts with generalizations and claiming centrality. Then the old methods are compared with the method used here to establish a niche. Some review of the previous research is also included here. After that the present study and the findings are stated. This article also includes the RA structure at the end of the introduction part.

In the fifth article (2007), we have all the four moves in the abstract part. That is purpose of the article, methods used; the results and the conclusions are all included in this genre. In the introduction part of the paper all three moves of Swales (1993) are present clearly. For establishing the territory claiming centrality is present and also a brief review of the previous research is presented. This article is organized smoothly taking into consideration all the moves and it is easy to follow.

Referring to the sixth article (1991), in the abstract part again all the four moves are present. The introduction part starts with some topic generalizations and a brief review of the previous research. Then there comes the niche and afterwards outlining the purpose and announcing the present study. Finally, we have the principal findings at the end of the introduction.

Table 2
The structure of research article introductions (Swales, 1990)

Move 1:Establishinh a territory	Step 1:Claiming centrality
	Step 2:Making topic generalizations
	Step 3:Reviewing items of previous research
Move 2:Establishing a niche	Step 1:Counter claiming
	Step 2:Indicating a gap
	Step 3:Question-raising
	Step 4:Continuing a tradition
Move 3:Occupying the niche	Step 1:Outlining purposes
	Step 2:Announcing present research
	Step 3:Announcing principal findings
	Step 4:Indicating RA structure

Tables three and four illustrate the graphical presentation of the data analysis on the six articles chosen from six different journals in the electrical engineering filed with the key word" Power System Stabilizers" to see whether the genres and the moves present are transferrable to teaching materials which can be used in classrooms or not.

Table 3
Number of moves present in the abstracts

Moves in abstract	Number of moves present in six articles
Purpose	6
Methods	6
Results	6
Conclusions	2

Table 4
Number of moves present in the introductions

Moves in introduction	Steps	Number of moves present in six articles
1. Establishing a territory	a) Claiming centrality and making generalizations	6
	b) Review of previous research	3
2. Establishing a niche	Indicating a gap	5
3. Occupying the niche	a) Outlining purpose	5
	b) Announcing present study	5
	c) Announcing principal findings	5

Results and Conclusion

This paper aimed to put another brick on the almost-new wall of the EAP and contribute to the previous findings in this field. To do so, six articles from six different journals in electrical engineering field were chosen to come up with some generalizations to ease teaching to the students of the field.

Although it is difficult to make generalizations from a limited bulk of data, some cautious results are stated here. Because the articles were chosen randomly and from the most prominent journals of the field the results are likely to be reliable.

It seems to the researchers that almost all the authors in this field include the three essential moves in their abstracts which are purpose, methods and results. Regarding the introductions, almost all the articles include the three moves stated in Swales (1990). A prevalent tradition which seems really important in this field is to compare the methods applied in the previous papers and then introduce the new ones used in the present study.

From what is stated above, we can say that our Research Hypothesis is partially supported and we can come up with some generalizations and commonalities to teach the students in a specific field although researchers believe that there should be some room for creativity as well.

One point we would like to discuss here is the format of the first article which sounds a little different, especially in the introduction part. It seems to the researchers that it goes back to the traditions of that journal. Even all the other headings were different from the other journals.

In summary, this paper is a contribution to the field of EAP and the researchers call for further research and more detailed and comprehensive analysis in order to come up with more reliable and exact generalizations.

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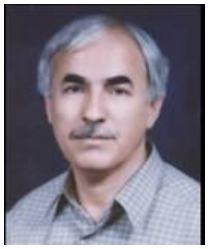

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Editor's Note: This paper stresses the important role of innovation to produce and share information within and between universities and the communities they serve. Innovation is essential for economic development in the competitive global environment.

Innovation Agenda of the Departments of Computer Education and Instructional Technologies

Adile Askim Kurt and H.Ferhan Odabas
Turkey

In today's global and competitive world, there is a process of cultural change regarding the use of technology, innovation, research and development, and production of technology. The increasing importance given to innovation in the whole world due to globalization is also increasing the expectations from universities – which are the primary institutions responsible for producing and sharing information. As a result, in almost all countries in the world, higher education has become the focus of societies and educational institutions have started to conduct studies necessary to make their policies appropriate to the changing paradigms. In this regard, Computer Education and Instructional Technology departments of education faculties of Turkey serve as a minor field to ameliorate the information society through implementing productive and most up-to-date instructional technologies to equip the workforce with fundamentals and specialties.

Keywords: Computer education, instructional technology departments, higher education, innovation, innovation types, Turkey.

Introduction

The word "innovation" derived from the Latin-originated word of "innovatu" is defined in literature as "the use of new methods in social, cultural and administrative environments for adaptation to the changing conditions." "Innovation" is defined in Oslo Guide as the application of a new process or a new product (good or service); as the application of a new marketing method; or as the application of a new organizational method in business applications, in work-place organization or in foreign affairs (OECD and European Commission, 2005). In other words, innovation is a process of transforming new ideas (products, methods or services) into valuable outputs. That is, innovation is the process of transforming new ideas into valuable products, services and methods beneficial for the society (Karataylı, 2008). This process is made up of two steps: revealing new and creative ideas and transforming these new and creative ideas into valuable products, services and methods (Vikipedia, 2010).

Innovation does not mean inventing the thing which is not discovered but it aims at discovering the ways of creating valuable things. Therefore, innovation does not simply refer to research and development or a discovery because innovation is a concept which requires constant learning and risk-taking as well as referring to developing different and various ideas, overcoming the problems previously unsolved and including different works.

There are four types of innovation: product, process, marketing and organization. Product innovation refers to the fact that a corporation or an institution develops a new and different product or changes the present product in a way to produce it with better qualities and superior features. Process innovation is the application of the method of a new or improved production or distribution. Marketing innovation is defined as the application of a new marketing method that includes important changes in the design or packaging of a product, in product placement, in product promotion or in product pricing. Finally, organizational innovation refers to the application of a new organizational method in the work-place organization of an institution or a company or in the foreign affairs of this institution/company (Elçi, 2006).

It could be stated that the most important tool that increases productivity is innovation. Therefore, for countries, innovation is the key to economic growth, increasing employment, social wealth and life quality (Elçi, 2008). In other words, in a country, an increase in employment and wealth depends on the innovation and adaptation capacity of that country. For the establishment of innovation economy in a country, there is a need for qualified and entrepreneur human force, a need for an environment that allows producing and spreading new ideas, a need for mechanisms supporting innovation and a need for the opportunities to access to capital. In other words, there is a need for policies besides human capacity, substructure, technology, institutional market and capital (Elçi, 2006). If we consider all these factors as inputs necessary for global innovation, the outputs of these inputs will undoubtedly be information, competition and wealth.

Innovation in Turkey

In today's global and competitive world, there is a process of cultural change regarding the use of technology, innovation, research and development, and production of technology. In this process of change, the competition between countries and regions is shaped via innovation; therefore, innovation is of great significance for the European Union (EU) that aims at becoming one of the most competitive economies within the scope of Lisbon strategy. One of the studies carried out depending on this significance is the European Innovation Evaluation initiated in 2000 for the purpose of comparing the innovation policies of European countries and of examining the innovation trends (European Trend Chart on Innovation) (Elçi, 2007). A report published in 2008 based on this evaluation shows the situation in our country, Turkey, as can be seen in Figure 1 below.

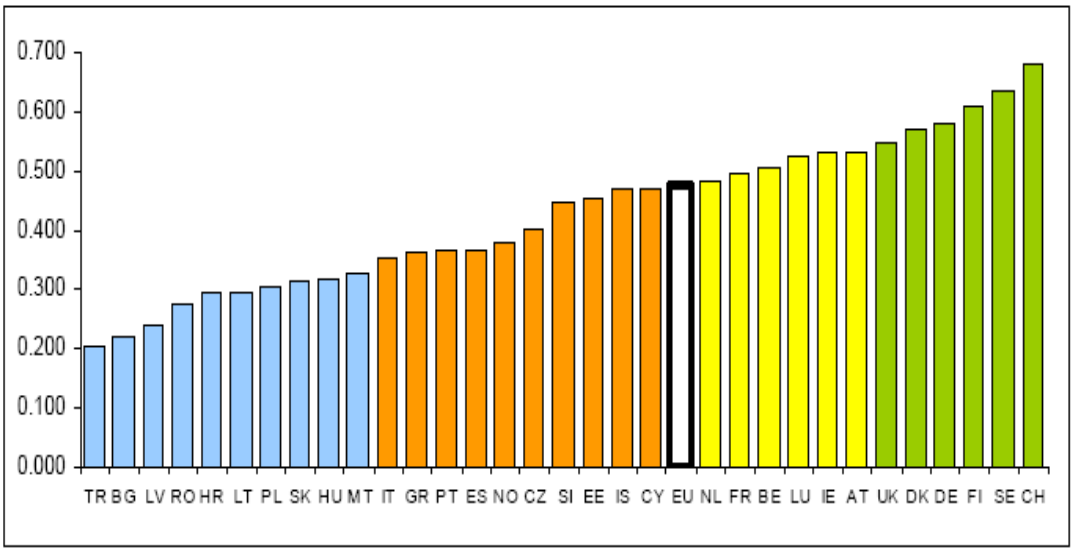

Figure 1.Innovation performances of countries

Figure 1 shows that our country, Turkey, is at the bottom of the chart based on an innovation index based on 29 different components. Regarding this result, it could be stated that there is not enough awareness of what innovation is and of how significant it is; that people are not open to renovation; and that the innovation culture has not yet been establishedt (Odabaşı, 2006). In addition, it could also be stated that lack of indicators belonging to Turkey, the small number of comparable data at international level and lack of timely collection of certain statistical data prevent a realistic evaluation of the innovation performance of our country. However, in recent years, there have been steps taken at national level, such as participation in EU Environmental

Programs; increasing governmental support for research and development; innovation which allows integrating innovation into the elementary school curriculum; and studies carried out on social basis such as National Innovation Enterprise (Elçi, 2007).

The increasing importance given to innovation in the whole world due to globalization also increased the expectations from universities – which are the primary institutions responsible for producing and sharing information. As a result, in almost all countries in the world, higher education has become the focus of societies, and the restructuring of higher education in a way to meet these increasing expectations was put on the agenda (CHE, 2007).

Higher Education and Innovation

Higher education faces an age of mass graduation at a time of rapid development in information and communications technology (Millwood & Terrell, 2005). Starting from the final quarter of the twentieth century, the process of transition to an information society has begun in developed countries and a new global economic structure called information economy has been established. In this new structure, the economic power of individuals is measured by their level of knowledge and education, and the competitive power of countries is measured in terms of human and social capital (CHE, 2007). In this process, because university-industry cooperation is a keystone of national innovation, advanced industrial countries and newly industrializing countries give great importance to this cooperation, take the necessary precautions on governmental basis to create a suitable environment for this cooperation and execute financial support programs to encourage this cooperation (Göker, 2001). A TrendChart report published in 2006 by the European Union drew the attention to the necessity of this cooperation and emphasized that companies should increase their cooperation with universities and research institutions to improve the innovation performance of Turkey (National Innovation Enterprise, 2006).

In our country, innovation in higher education has been accelerated with the Bologna and Lisbon process and continues with the studies of the Council of Higher Education (CHE) and of the Commission of Higher Education Academic Evaluation and Quality Development. The Bologna process including the years between 1999 and 2010 pointed out that universities, the political authority and the economic powers should be independent; that education and research should be conducted together at universities; that university life should be open to tolerance, dialogue and information sharing; and that universities should overcome geographical and political limitations to obtain global information (Erdoğan, 2010; Odabaşı, 2006). The Lisbon process, like the Bologna process, pointed out that universities should be independent of political authority and economic powers and that the European Union should have a competitive and information-based economy by providing its citizens with better jobs, life standards and social statutes via economic growth. In addition, issues such as avoidance of social exclusion, active citizenship and personal development as well as for the areas of life-long learning, competition and business, are among the basic elements of the Lisbon process (Aktan, 2007).

Taking the areas mentioned by both processes as basis, the Commission of Higher Education Academic Evaluation and Quality Development (2005) focused on increasing the quality in higher education and pointed out that the quality levels of academic and administrative services in higher education institutions should be improved; that cooperation between countries should be developed regarding quality assurance within the scope of the Bologna process; and that studies should be conducted to establish international consistency (Odabaşı, 2006). Besides these, the following activities could be mentioned as innovation activities in higher education: student activity that allows students to study abroad as a student in an higher education institution that has Erasmus University Certificate in a European country for one or two academic terms in year as mentioned in the CHE strategy report; program activity that allows students to enroll educational programs of another country and to get a grade without going abroad and especially by using

distant educational techniques; and institutional activity that allows universities in developed countries to give education in campuses that they have founded in other countries (CHE, 2007). The increasing number of students, the growing technological innovations, and disability of the current programs to meet the needs, rapid production of information, and the importance of having quality and being different constitute the basis of all these innovations in higher education (Odabaşı, 2006). Based on these innovations, distance education applications are gradually increasing in our country; studies on updating the programs are conducted; and multi-national projects are executed for diploma equivalence, European Credit Transfer System (ECTS) and for student and instructor exchange within the scope of international cooperation. One of the areas in which such studies are conducted based on the rapidly developing information technologies (IT) is the department of Computer Education and Instructional Technologies (CEIT) in education faculties in Turkey.

Table 1
Innovative issues for CEIT departments

	Student	Faculty member	Content	Institution
Product	Learning to learn	Instructional leader Learning partner Facilitating integration of ITs into educational environments	Structuring the content with respect to student profiles of the new millennium Rapidly changing content	Life-long learning Entrepreneurial university governance Patent studies Leading studies in education (open education, opportunities for the handicapped, civil aviation etc.) Integration of IT into educational environment
Process	Learning through new instructional methods and techniques Learner roles specific to the information era	Using new instructional methods and techniques Recognizing students with respect to their differences, characteristics and needs	Different ways of presenting the content (online, e-learning etc.)	Cross-border higher education studies e-learning Inter-disciplinary education Multi-disciplinary instruction Accreditation
Marketing	Participation in student exchange programs Taking part in inter-disciplinary projects Taking part in more than one higher education program (second university, certificate programs etc.) Introducing oneself in virtual environments	Participation in instructor exchange programs Taking part in inter-disciplinary projects Introducing oneself through good-quality publications	Interactive multimedia	Academic -activity Advertisement through different media channels Competitive studies
Organizational				Cooperation with different institutions (industry, university etc.) Virtual instructional applications

CEIT and Innovation

CEIT departments, established within the scope of the restructuring of CHE education faculties and the number of which is 43 according to the data of the academic year of 2010-2011 aim at training teacher candidates to help them become effective in both the technological area and the educational area by equipping them with the updated instructional technologies and methods via multi-disciplinary approaches and contemporary instructional applications. The updated educational programs of CEIT departments and the coordination to be established between these departments in modern Turkey are the necessary steps to be taken to conduct innovative studies. In this respect, the following studies were conducted in CEIT departments; opening instructor-training programs that could contribute to training qualified faculty members; exchange programs like Erasmus and Farabi that support student and instructor exchange; equipping students with contemporary instructional methods and techniques; taking the responsibility for the integration of current technologies into education; opening distant education programs to provide a larger population with educational opportunities; standardizing graduate and post-graduate programs; and conducting interdisciplinary project studies. For the execution of all these processes, it is necessary to establish coordination between CEIT departments and to help universities, faculties and related institutions work in cooperation. In this respect, the process that occurs with different variables such as students and faculty members who constitute the building stones in innovative studies conducted in the light of new paradigms in CEIT departments in higher education is summarized in the Table 1 below.

Conclusion

Information society is a developmental phase that conveys the society beyond industrial society with respect to economic, social, cultural and political issues through new developments such as communication technologies, information highways, and electronic trade (Aktan & Tunç, 1998). In this phase, the information industry, information production, information capital, qualified human factor and educational consistency gain importance with the development of new basic technologies. Although innovation has a key role in the information-based economy of this society, the complexity of the process makes it difficult to understand innovation. Easier communication, skills and different ways of transferring information make it necessary to include innovation in governmental policies and to establish cooperation between institutions. In this respect, the paradigms that occur in information-based economies have influenced educational systems; thus, educational institutions have started conducting necessary studies to make their policies appropriate to the changing paradigms. In this regard, the CEIT departments serve as a minor field to ameliorate the information society through implementing productive and most up-to-date instructional technologies to equip the work power with the fundamentals and specialties (Odabaşı, Akbulut, Dursun & Çoklar, 2009). It could be stated that CEIT departments, using ITs effectively, are departments in which innovations are carried out with changes and transformations in higher education in Turkey.

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Editor's Note: Learning Management Systems (LMS) integrate a wide range of functions related to teaching, learning, and management of the learning process. Integration with powerful tools such as artificial intelligence, mobile agents, and "cloud" technologies enables teaching and learning programs customized to individual learner needs and responsive to more nearly simulate live instruction. The authors of this paper take us to the next level of design for e-assessment systems.

A Framework of Mobile Agent Based E-Assessment System

Anbo Meng, Luqing Ye, Romuald Stock
China and France

Abstract

So far, the traditional online assessment mechanisms rely mainly on the client-server model. Such mechanisms usually do not scale well and do not fully support features like evaluation of subjective questions, delivery of dynamic content, off-line examinations, or proactive event notification etc. To address the issues mentioned above, an innovative holistic solution is proposed to model a large-scale on-line assessment system by applying the new generation of mobile agent technology. In this paper, several mobile agents apply to four typical e-assessment processes: test generation, delivery, evaluation and result publishing. Since mobile agents are autonomous and dynamic entities that have the ability to migrate between various nodes in the network, which offer many advantages over traditional design methodologies such as reduction in network load, overcoming network latency and disconnected operations. With further development of agent and network technology, it will bring an alternative option for the large-scale application of the mobile agent paradigm to e-assessment domain.

Keywords: Multi-agent system; Mobile agent; E-assessment; E-education;

Introduction

As is well known that whether in e-Education programs, or the traditional education environment, teaching and assessment cooperate as a complete learning cycle. In e-Education context, the e-assessment plays the same role as classroom based assessment but has the potential to provide more flexible and innovative assessment approaches.

Although the benefits of e-Assessment are exciting and attractive from both learner and tutor perspective, its potentials are far from being brought into play. As Latomaa pointed out, preliminary searches for good examples of online assessment reveal no mainstream examples of the potential of the new media to construct authentic, flexible and meaningful evaluation of the range of learner learning[1]. Some of this lack of innovation in assessment may stem from the perception that e-Education is somehow "second class learning." Hence, universities undertaking e-Education assessments will not stray far from the assessment practices of face-to-face traditional teaching as they recognize that only by meeting such normal quality standards will you be recognized as being serious and the results of your teaching effort may result in accreditation in the university context [2]. However, a study of e-assessment confirms that the principles for quality e-assessment are the same regardless of the delivery mode. In other words, validity, reliability, fairness and flexibility are the key measures for quality assessment.

From the literature, it is found that the traditional computer based assessment mechanisms, such as Web Based Testing (WBT), rely predominately on the client-server model. Java Applets and scripting languages like Java Script etc. are the frequently used techniques to enable front-end client processing. Common Gateway Interface (CGI) scripts or Java Servlets are the most often used techniques for server side processing. Such mechanisms usually do not scale well and do not fully support features like automatic test generation, evaluation of subjective questions, delivery

of dynamic content, off-line examinations, flexible communication between online evaluation components, and proactive event notification, etc. Obviously, these features are extremely desirable for e-assessment and there is a need for alternate ways of designing such applications.

Based on the above analysis, this paper puts forward an innovative holistic solution to modeling a large-scale on-line assessment system by applying the new generation of mobile agent [3-5]. The promise of mobile agent paradigm makes it possible to address the above issues in a natural and elegant fashion.

Mobile agent system

As a valuable alternative to the traditional programming model, the mobile agent paradigm involves the mobility of an entire computational entity, along with its code, state and probably the potential resources (e.g., ontology schemas) from host to host on a network. Generally, the itinerary map used to travel through different network nodes can either be predefined or determined by the mobile agent on the fly, based on the its current state or its computing logic.

As compared with the traditional client-server model, the mobile agent paradigm has several advantages with respect to communication latency and bandwidth, asynchronous execution, dynamic adaptation, protocol encapsulation and parallel execution and so on. Although the mobile agent technology has not yet found its way into today's more prominent applications, the potential benefit of the mobile agent paradigm has been widely accepted, especially in the past few years when several mobile agent middle platforms such as JADE, Aglets and Voyager have emerged, which greatly stimulated and promoted the development of mobile agent-based applications.

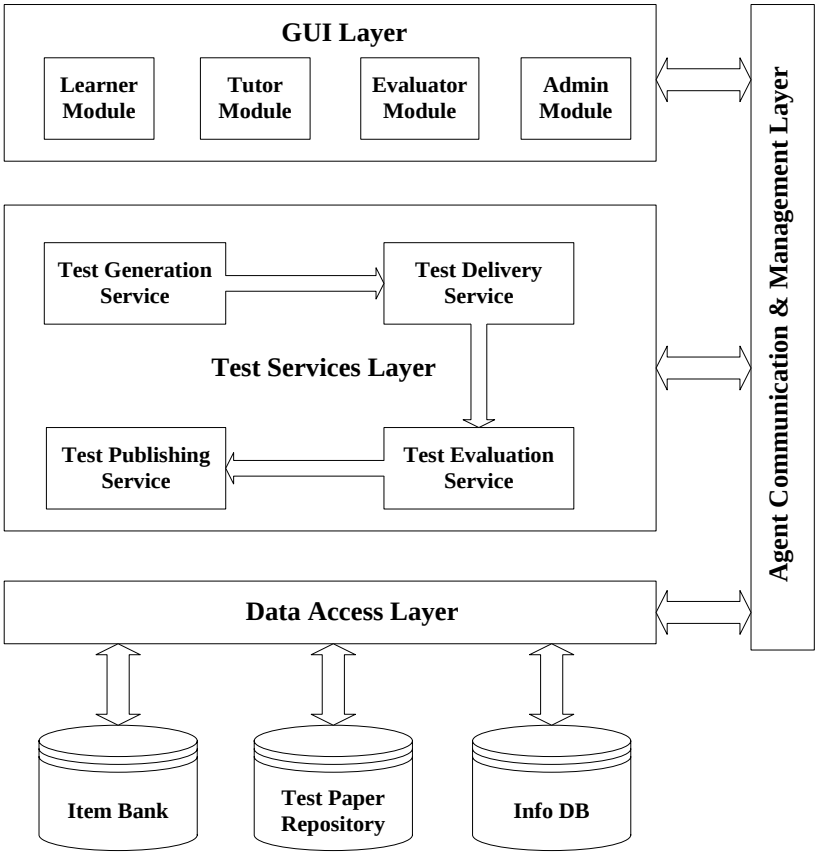

Figure 1: Architecture of MAEES

Overall function structure

As shown in Figure 1, the architecture of Mobile Agent Based E-assessment System (MAEES) proposed in this paper is built on four layers from the functionality perspective; i.e., GUI layer, Assessment Service Layer, Data Access Layer, and Agent Communication & Management Layer. It is worth noting that, in MAEES, different agents on behalf of particular services, applications, or human actors, either mobile or static, reside on client-side or server-side machines that may be physically dispersed over the internet. This is natural because of the characteristics of the e-assessment environment where different actors such as learners, tutors, test evaluators, administrators are typically located around the world.

In particular, in GUI layer, there exist four types of users who participate in the e-assessment process: learners, tutors, evaluators and administrators. They play different roles. More specifically, a learner is the candidate who takes the assessment. A tutor is the online course author or the teaching organizer who is responsible for preparing the paper by taking advantage of the read-made test generation service in the test service layer, which has the capability of automatically generating test papers according to the requirements specified by the tutor. An evaluator takes charge of the evaluation of subjective questions. An administrator is responsible for the registration, authentication of all roles. All the roles mentioned above are supported by their personal assistant agents (personal secretaries) assisting in performing corresponding tasks.

In the test services layer, the four core components: test generation, delivery, evaluation and result publishing are integrated with each other and, however designed as autonomous service providers, may run on different servers. In particular, the main feature of this architecture is that all the online assessment components are designed as several independent services represented by corresponding autonomous mobile agents that have the capability to migrate to the appropriate destinations and carry out local computation. This innovative paradigm and design philosophy bring several benefits such as bandwidth reduction, independent network connectivity, and enhanced robustness and flexibility.

The data access layer provides the bridge to connect databases and agents that need particular data access services, which are, in fact, also implemented as utility agents.

The agent communication and management layer is the runtime environment that provides the common communication channel for the interaction among agents as well as provides management service (e.g., white service or yellow service).

Architecture of test generation service

Figure 2 shows the proposed architecture of test generation service, in which there exist several types of agents (mobile or static) that might be geographically dispersed on different internet nodes.

Tutor Assistant Agent (TAA) is a personal assistant agent that performs some particular tasks on behalf of a teacher. For instance, the agent can help a teacher set up initial parameters, search other agents providing such service as composing tests, and eventually display or edit the final result etc., For the tutor's convenience, this agent can be downloaded on remote machines together with an applet and then run in local Java Virtual Machine.

Test Generation Service Agent (TGSA) is responsible for offering automatic test generation service. It runs persistently on a test generation server that provides a runtime environment for all agents as well as manages their lifecycle. In fact, TGSA plays the role of agent factory, which possesses the ability to dynamically produce mobile agents that migrate to remote item bank servers to perform the task of automatic test generation. A test generation algorithm based genetic algorithm can be referred to [6].

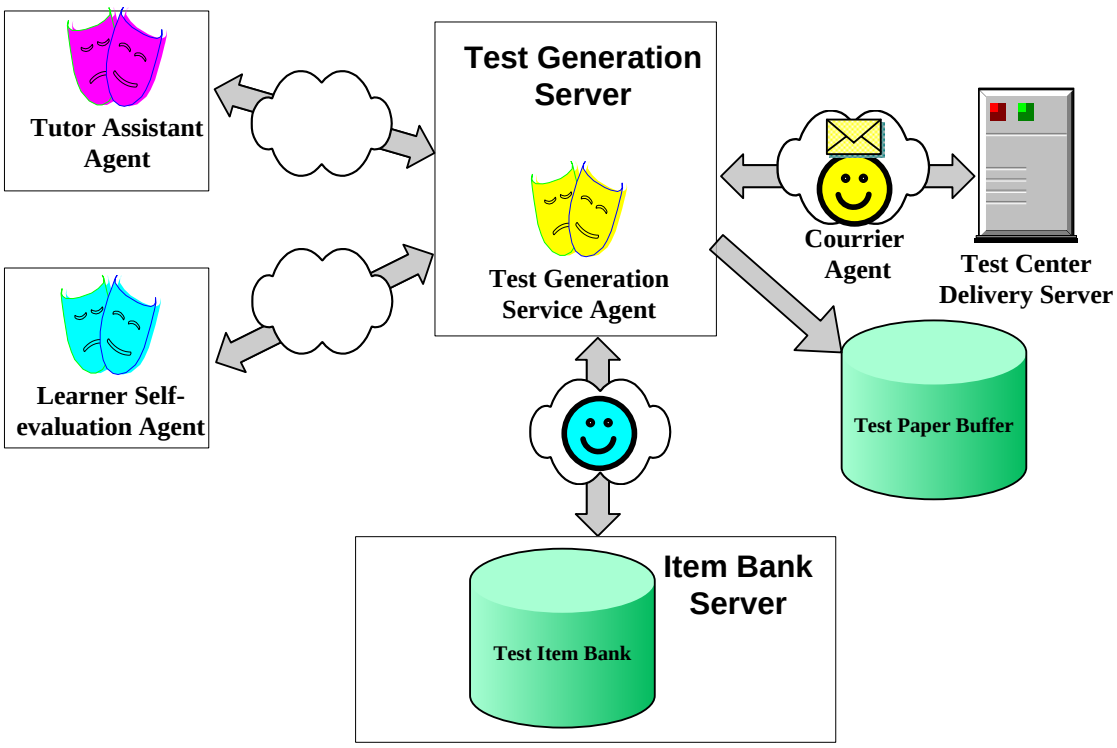

Figure 2: Architecture of test generation

Courier Agent (CA) is a mobile agent that is responsible for dispatching test papers to different Test Delivery Center Servers (TDCS). This agent is created by TGSA after the generated test paper is verified, edited, and confirmed by the test setter (i.e. tutor). Once TDCS is not available for some reasons(e.g, busy, or disconnection of network), such test papers can buffered in temporary database so as to wait for appropriate time to send CA to corresponding destinations.

Design of delivery

As shown in Figure 3, this stage of test delivery mainly involves: distribution of test paper to different test delivery center servers, creation of Delivery Agents that are responsible for delivering test paper to distance learners (examinees), and creation of Answer Agent that is responsible for compiling answers collected by delivery agents.

It is obvious that the architecture shown below exhibits to a great extent the flexibility as most of the activities in this stage are performed by mobile agents (such as Answer Agent, Courier Agent, and Delivery Agent). In particular, we describe in detail the three stages:

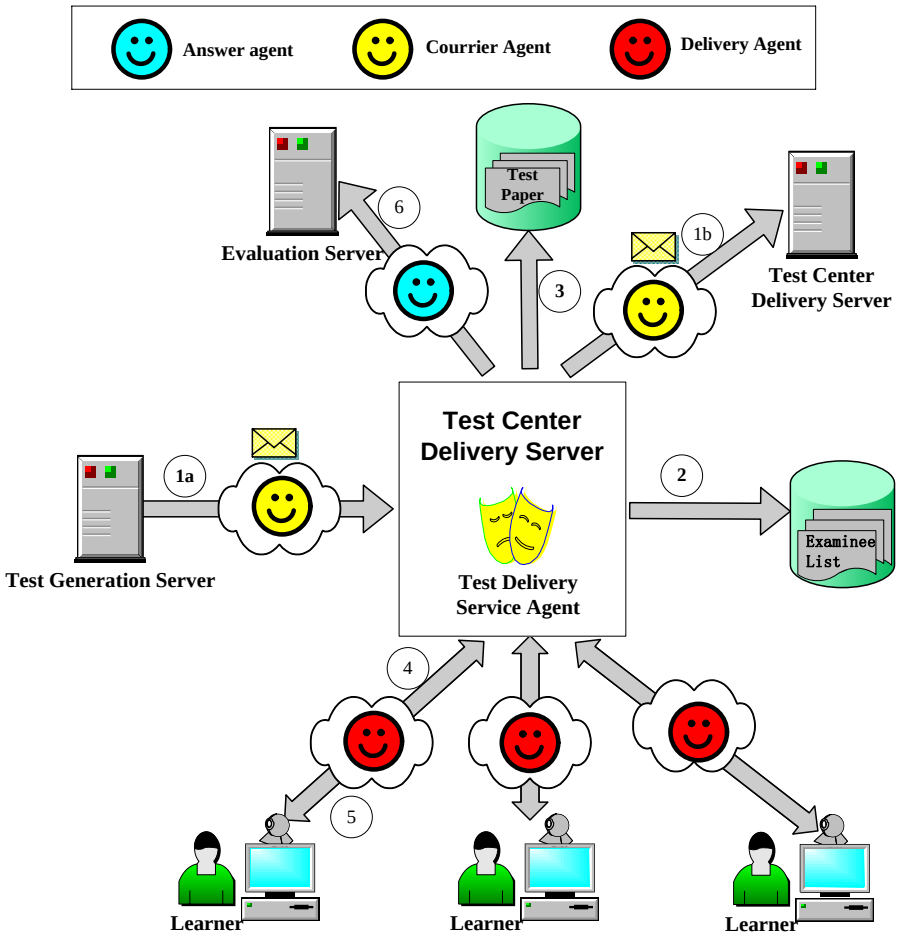

Figure 3: Architecture of test delivery service

1. Distribution of Test Papers Among Delivery Centers

In large-scale online test environment, there may exist several test delivery centers which may locate on different network nodes at which learners register with the vicinal servers. As described in the previous section, the Courier Agent is created by the Test Generation Service Agent (TGSA). Upon supplied with prepared test paper and itinerary of the specified test delivery centers, this agent will migrate to the first Test Center Delivery Server (see step 1a) as long as this operation is permitted and authorized by Test Delivery Service Agent (TDSA) running within this server. After leaving over a copy of the test paper in the local databases (see step 3), the Courier Agent moves on to the next location (see step 1b). Upon completion of the itinerary, it returns to the Test Generation Server and terminates if no any abnormity occurs. Or else, the above process needs to be repeated. If the number of test delivery centers is large, more than one Courier Agent may be launched in parallel.

2. Creation of Delivery Agents and Testing Service Agent

One of the tasks to be performed by Test Delivery Service Agent (TDSA) is to detect the exact moment when a scheduled assessment should be triggered. Of course, the time of assessment can be predetermined by tutors, administrators (in case of compulsory summary assessment), or even the learner himself (in case of self-evaluation). Once a compulsory assessment needs to be launched, the personal agent of each learner who has to take the assessment (according to the examinee list (see step 2) registered at this test delivery center) will receive one notification of

information about the upcoming assessment. When any learner prepares well for taking the test, his/her personal agent has to respond with a message requesting the migration of Delivery Agent. Then TDSA begins to create and initiate one Delivery Agent per examinee. Once these Delivery Agents have extracted the specified test paper, they start to migrate via network to the corresponding learner's machine. If necessary, the Delivery Agent may carry with utility tools for purpose of facilitating the process of answering question items. Thanks to the mechanism of mobile agent paradigm, the learners can take offline test. During the testing process, the Delivery Agent presents the questions to a learner and records his/her answers. When the designated examination duration terminates or if the learner finishes ahead of schedule and wants to submit the results, the Delivery Agent returns to the Test Delivery Server with the answers (see step 5). It is worth noting that when the type of assessment is self-evaluation, for rapid feedback we assume that the test just consists of objective question items without any subjective item. In this situation, the test can be automatically evaluated by Delivery Agent and the learner can see the test result immediately.

3. Creation of Answer Agents

The Test Delivery Service Agent needs to create another type of mobile agent ─Answer Agent that is used to extract answers from the Delivery Agent and is later sent to the Evaluation Server. Note that while the Delivery Agent itself could be sent to the Evaluation Server, we use a separate Answer Agent to ensure security and anonymity.

4. Design of evaluation & result publishing

This stage involves: evaluation of answer papers and compilation and publication of test results (see figure 4).

Evaluation of Answer Papers

If the type of assessment is mandatory formal examination, we assume that the test paper consists of both objective and subjective question items. As a result, the part of objective question items can be evaluated automatically by machine while the part of subjective items must be evaluated by human evaluators. Accordingly, we describe the two types of evaluation process as follows:

1. **Evaluation of objective question items**: the Answer Agent together with the "answers paper" arrives at the Evaluation Server (see step 1) with the permission of Evaluation Service Agent. The part of subjective question items (e.g., writing essay) in the answer paper will be saved into local database (see step 2) for the preparation of subsequent evaluation by distance test evaluators where appropriate. However, for the objective question items (e.g., true/false, multiple choice, matching etc.), they can be sent to the evaluation engine (see step 3) where the correct answers associated with these question items have beforehand been stored. After Evaluation Engine finishes this evaluation process, the final results/scores need to be stored in result buffer database (see step 4).
2. **Evaluation of subjective question items**: the division of work among several evaluators is especially of signification as it is unimaginable that a single tutor can evaluate hundreds of test papers. This situation is closely similar to the traditional pencil-pen-paper based large-scale examination. Whereas, the incorporation of mobile agent paradigm largely enhances the flexibility, independently of time, space, and connectivity of network. With regard to the issue how to distribute among evaluators which separate part within a test paper to be evaluated, it can be negotiated beforehand through their personal assistant agents. Once they come to consistent agreement, all relevant information will be registered with Evaluation Server. When everything goes smoothly, the manual evaluation process begins to happen. More specifically, Evaluation Service Agent sends messages to all the evaluators who are responsible for evaluation of one

specified test paper, notifying that the answers to be evaluated are already ready. If any evaluator is available online and request to launch his/her evaluation process, Evaluation Service Agent start to create Allocatee Agent that is responsible for extracting, from the local answer bank, the predetermined portion of question items belonging to the share that the evaluator should do. After obtaining the destination address of the evaluator from registration info database (see step 5), the Allocatee Agent then moves to the evaluator's machine (see step 6), Once arrival, it presents a Graphical User Interface to the evaluator and prompts her to evaluate its answers. When the evaluator completes relevant evaluation work within allowable duration, Allocatee Agent will carry the evaluation result and returns to Evaluation Server. Eventually, the result is likewise stored into the result buffer database temporarily (see step 7), waiting for the appropriate time to later be sent to the Result Publishing Server. In particular, When all the answers have been evaluated, Evaluation Service Agent creates Report Agent that is responsible for assembling all the answers and then move to the Result Publishing Server (see step 8) with the permission of Result Publishing Service Agent.

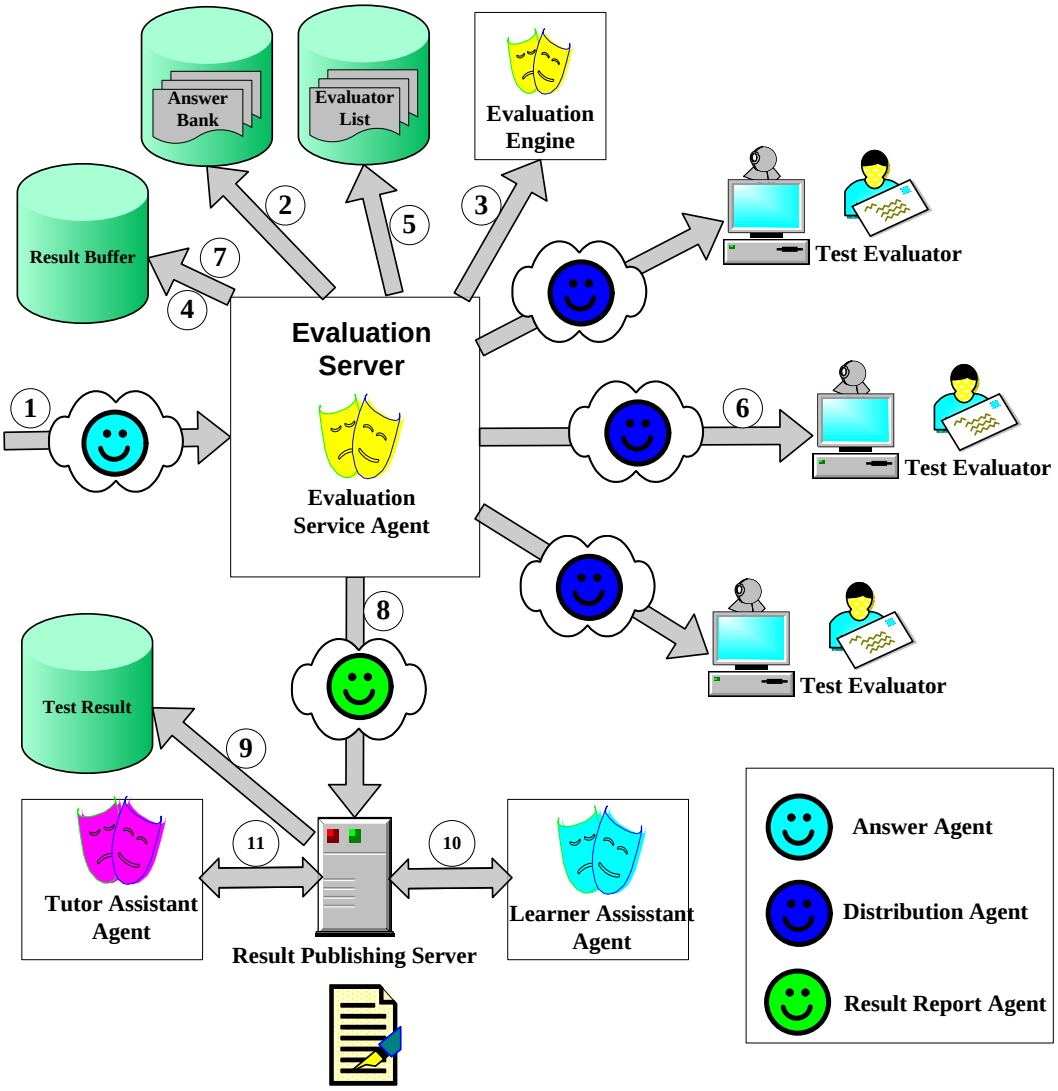

Figure 4: Architecture of evaluation and result publishing

Publication of Results

After Report Agent arrives at Result Publishing Server, result data are persisted in local database. Eventually Publish Service Agent compiles, analyses and publishes the final results. In particular, it sends messages including final test results to relevant personal assistant agents (see step 10, 11) on half of different users (tutor, or learner).

Conclusions

This paper put forward an innovative holistic solution to modeling large-scale on-line assessment system by applying the new generation of mobile agent. These agents are applied to the four e-assessment processes: test generation, ,test delivery, evaluation and result publishing, the core functionality is mostly carried out by relative mobile agents, as compared with the traditional client-server computing paradigm, the advantage is obvious such as: Communication latency and bandwidth, Asynchronous execution, Protocol encapsulation, parallel execution.

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Editor's Note: If you can define the problem, this may be a key to defining a solution. The information age was made possible by ubiquitous and universally available computer technologies. Online learning is an excellent tool to expand access to educational programs. However, it is only feasible if computer technologies are ubiquitous and universally available. Often there is a chicken-and-egg type problem where, in order to be effective, training to use a new technology must be synchronized with its introduction and implementation.

Technology and Distance Education Programs at the University of Botswana

Regina Masalela and Tshepo Batane
Botswana

Abstract

Technology has potential to enhance and expand access to distance education for adult learners. This study investigated the use of technology in the delivery of distance education programs at the University of Botswana. The findings of the study indicated that despite the availability of technological resources at the university and wide access to technology by learners, there was very minimal utilization of technology in the delivery of Distance Education programs. Lack of technological services in rural areas was identified as the main reason why tutors were reluctant to use technology in the delivery of distance education to adult learners. The university does not compare favorably with other Distance Education programs around the world in terms of technology. The study also revealed a steady decline in enrollment in Distance Education programs at the university. The paper recommends rigorous adoption of technology by Distance Education programs at UB so as to enhance learning and also widen accessibility to the programs.

Keywords: Distance education, adult learners, technology, online learning, access, digital divide, urban areas, rural areas, course delivery.

Introduction

The University of Botswana (UB) is the only national university in the country and plays a major role in the delivery of distance education (DE), specifically to adult learners. The university has included in its vision statement "lifelong and open learning approaches" as focal points for the institution. The institution, therefore, is committed to increasing access to education by providing more opportunities for participation in tertiary education. The university's vision for distance education is that it "will be provided as an integral part of the overall strategy to make higher education and lifelong learning more accessible and more available to Batswana and others wherever they may live"(UB website). As a result, the university offers distance education programs through the Centre for Continuing Education (CCE) which was established in 1994 to deliver distance education programs through its department of Distance Education. The programs that are currently offered by the department include the following: Diplomas in Adult Education (DAE), Non-Governmental Organization (NGO), Youth Development Work (DYD) and Business degree in the areas of accounting, finance and marketing.

In 2001, UB launched the eLearning programme which was defined as "the appropriate use of ICTs for advancing student-oriented, active, open, collaborative and life-long teaching-learning processes' (Uys, 2003). Various technologies were provided by the university for use in teaching and learning. Online learning was also launched and WebCT was chosen as the Learning Management System to be used to deliver courses online using a blended approach. The use of WebCT has grown tremendously in the mainstream programs rising from six courses in 2001 to an average of 375 courses in the past few semesters. The purpose of this study, therefore, was to investigate how much of this technology was being utilized in the delivery of DE programs at

UB. The study also identified factors that influenced the use of technology in DE programs and establish how DE programs offered through UB, compare with other DE programs around the world in terms of technology usage.

Literature Review

Technology has revolutionized distance education in a profound way. DE has changed dramatically over the years from being primarily print-based to being technology-based (Rahman, nd). Application of technology in DE programs include use of television and satellite technology or using computers such as the internet to carry out learning (Eddy & Spaulding, 1996). Technology is believed to re-engineer education systems. Most academic institutions adopt the use of technology to remain competitive and attract new clients. The main aim of DE is to expand access to education so that it reaches certain populations of learners who cannot attend conventional school because of various reasons such as being employed, travelling expenses that are prohibitive and lack of time due to other commitments. The ultimate goal is to acquire knowledge that would be beneficial to them in various aspects of their lives. Most distance learners are professionals who are returning to universities for both personal and professional reasons (Stamps, 1998).

Many institutions have incorporated the use of technology in their DE programs as a way to expand their accessibility and also enhance their quality. The use of technology in the delivery of distance education has been credited with the ability to open up even more access to learning as issues of travel and time are taking care of (Lever-Duffy,

, 2003). Learners can work on their courses at their own convenience. Flexibility has been reported as the greatest benefit of online learning as learners have the opportunity to access course material anytime, anywhere and at their own pace. This is a great advantage to adult learners as most of them are very busy people (Newman, 1997). Kochmer (1995) says flexible learning opportunities have become very popular among many people who would otherwise not get an opportunity to access formal education.

Communication tools such as e-mail, discussion forum, and chat-rooms, that are often embedded in course delivery systems assist to promote interactivity in the course. Learners can easily communicate with their instructors or among themselves. Online communication provides various ways of interactivity both synchronous and asynchronous. Shareef and Kinshuk (2005), states that synchronous communication has transformed distance education from an individualized model of communication to a more interactive one. Learners can work on online collaboration projects. Technology offers opportunities for self-directed learning and student centered learning by allowing learners to research and construct information on their own. Adult are responsible for their own learning, so they need freedom to direct themselves. Online learning has also been credited for improving the learners' writing skills because communication is mainly done in writing. Technology offers greater diversity in the delivery of distance learning programs (Kelly-Salinas (2000).

Many institutions around the world offer distance learning programs and world-wide trends indicate that the use of paper to deliver instruction and postal communication has been greatly substituted by online presentation and communication. Institutions use technology in various ways to deliver their courses. Some examples of these institutions are, Mercer University, which delivers its programs on a two-way interactive compressed video system (Duvall & Schwartz, 2000. This helps to cater for people at their respective locations who are employed and would not be able to come to the institution physically. In the US, millions are enrolled in courses offered through television. Satellite television networks have been widely used to deliver various kinds of education around the world (What is distance education? 2005). Many universities offer complete

degree programs through the internet, for example, California Virtual University which offers a wide range of degrees and courses from different universities. Other examples are: Indiana University Online, Western Governors University and many others. The British Open University is regarded as the pioneer in this area. It was developed in 1971 and it offers degrees to anyone around the world who has access to the internet. Many universities around the world have copied, it such as: Open University in Japan, University Courses to Degree Level for Part-time Adult Students in France, The UNRWA/UNESCO Institute of Education in Beirut, The Empire State College in New York (Towhidi, 2010). Other places are now even introducing virtual high schools.

Australia is said to be an international leader in online DE programs and it has taken federal state funding and planning to make that happen. (Askov et. al., 2003). Askov says Australia's intention is to become an international leader in utilizing new technologies to vocational and adult education through the Australian Flexible Learning Framework for National VET. This is a government's effort through well-established goals and strategies. The country tries to follow constructivist and social learning philosophical models in designing and delivering their programs.

Other countries that have demonstrated effective use of technology in the delivery of their DE programs are places such as India. Since early 1990s, India has taken advantage of satellite broadcasting with interactive technologies of telecommunication to distribute learning to various sections of the society (Patel, 2002). This required a concerted effort from the government. Kenya also has the reputable School of Continuing and Distance Education which was started in 1953. Historically, the school used correspondence study, but now utilizes audio, video and computer technologies to deliver learning. The University of Pretoria in South Africa used Short Message Service (SMS) as a learning support tool (Viljoen etal, 2005).

Enrollment numbers for DE programs around the world are growing tremendously, for example, in the US, during the academic year 2000-2001, there was an estimate of 3 million enrollments in DE courses offered in both 2 year and 4 year institutions. This number grew to 12.2 million in the academic year 2006-2007 (National Center for Education Statistics, 2008). Various technologies are being utilized to meet the needs of these people.

Methodology

Participants in this study were learners enrolled in the DE programs at UB. A total of 50 learners participated which was 90% of total learners enrolled in the programs. Course tutors in the various programs were also included in the study. This study triangulated both qualitative and quantitative techniques in collecting data. The methods used were interviews, surveys and document reviews. The distance education program at UB is structured such that students come to campus three times in a semester for face to face tutorials. So this study was conducted during one of these on-campus sessions. Questionnaires containing both open and close ended questions were administered to the learners at the beginning of their class sessions and there was a 100% return rate of the questionnaires. Interviews were conducted with course tutors. SPSS 18.0 was used to analyze the quantitative data, while categorization, synthesis and search for patterns were techniques used to analyze qualitative data. The questionnaire for the learners was administered first because the information they provided was needed to seek answers and clarifications from the tutors and administrators. This helped to get a complete picture of the status of technology use in DE programs at UB.

Findings

The study indicated that there were more female participants than male, which was a true reflection of the entire DE programs enrollments.

Tables 1- 3 below present the demographic information of participants.

Table 1
Gender of participants

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	14	28.0	31.8	31.8
	Female	30	60.0	68.2	100.0
	Total	44	88.0	100.0	
Missing	System	6	12.0		
Total		50	100.0		

Table 2 indicates that a majority of participants in this study were aged between the ages of 31-40 years. Adult education programs are self-sponsored so many people often work a few years after graduating to accumulate some money to sponsor their studies

Table 2
Age of Participants

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	20-25	4	8.0	8.2	8.2
	26-30	4	8.0	8.2	16.3
	31-35	17	34.0	34.7	51.0
	36-40	11	22.0	22.4	73.5
	41-45	10	20.0	20.4	93.9
	46-50	3	6.0	6.1	100.0
	Total	49	98.0	100.0	
Missing	System	1	2.0		
Total		50	100.0		

Table 3 shows the different places where the participants lived and worked. In Botswana, there is only one city which is the capital city of the country and that is where they majority of the working class live. This is also reflected in this study as the majority of the participants lived in the city. Towns are well developed with many services and work opportunities but not as advanced as in the city. Big villages are where the majority of the population lives. A typical structure of a big village is a mixture of both urban and rural life. These villages are often well

serviced with good infrastructure. Most big villages in the country are within close proximity to either the city or towns. Small villages and remote areas are often referred to as the rural parts of the country. These are characterized by small populations with small villages having a little more than remote areas. In remote areas the small population is often scattered over a large area of land, making it very difficult to provide resources in these places. This study revealed that very few learners came from the rural areas.

Table 3
Place of work for the participants

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	City	24	48.0	50.0	50.0
	Town	2	4.0	4.2	54.2
	Big Village	17	34.0	35.4	89.6
	Small Village	3	6.0	6.3	95.8
	Remote Area	2	4.0	4.2	100.0
	Total	48	96.0	100.0	
Missing	System	2	4.0		
Total		50	100.0		

The findings of these study revealed that there was very minimal use of technology in the delivery of DE courses at UB. Evidence showed sporadic efforts by individual tutors to use technology in their courses, such as using e-mail with their students, but the majority of the programs were predominantly print-based. The tutoring sessions were mostly teacher-centered (lecturing). Assignments were paper-based and hand delivered or sent by postal mail. Generally, there was very little interaction between the learners and tutors outside tutoring sessions. This was the same case even among the learners themselves. However, both learners and tutors believed that technology would be very beneficial to their programs.

It was interesting to note that even though participants reported very little usage of technology in the delivery of their individual courses, they reported high use of technology in their own self-study such as typing their assignments or searching for information in the web. 70% of the participants rated their computer literacy level between high and average. 80% of the participants indicated they had access to a computer that they could use for school work if they needed to. 82% of those computers were reported to be located at work, 11% home owned and 4% were at an internet café. 85% of these computers were reported to be connected to the internet. A cross-tabulation analysis indicated that the 20% who indicated no access to computers were actually located in urban areas, and all rural dwellers reported access.

This study revealed that a majority of tutors in the DE programs were UB lecturers. It was also discovered that these lecturers were well trained on the use technology in learning and they extensively used WebCT and other technological resources in their mainstream classes. However,

when the learner participants were asked whether they were familiar with WebCT, 70% of them indicated that they had never heard of it.

Interviews were conducted with administrators and tutors of DE programs at the university to find out why technology was not being utilized in the delivery of these programs. The interviews revealed that the main reason for the limited use of technology in DE programs was lack of technological resources in rural areas. Most tutors believed that using technology to deliver their courses such as online delivery would disadvantage learners living in rural areas who would have problems accessing the material. One respondent said "I do not have a problem with putting my course online, but what about that student who lives in the rural area, how will they access it? It will not be fair for them." Other reasons provided for not using technology were: lack of training, especially by those tutors who were not UB employees and lack of technical support for students at their respective sites.

The study revealed that enrollment numbers in DE programs at UB have declined significantly to a point where the programs are facing a danger of being discontinued as per the university regulations which requires courses to have a minimum of five students. It was discovered that some courses had as little as three students in a class.

Discussions

This study illuminated that there was very little utilization of technology in DE programs at UB. The programs in general were very traditionally-based. This stands in stark contrast with a majority of DE programs around the world which have become very technology-based with some completely offered virtually through various technologies. This lack of technology use in DE programs certainly does not support the university's vision of becoming "a center of excellence in Africa and the world." (UB vision). Research has shown that technology plays a very important role in assisting institutions attain their educational goals (Mingle, 2002); therefore, UB needs to seriously consider harnessing the potential of technology in enhancing its DE programs.

The declining enrollment numbers for DE programs at UB is a cause for concern. This paper argues that the use of technology in the offering of the programs can assist to reverse this trend because it will open up more access and flexibility to the courses. The study showed these programs are predominantly print-based which means they are not widely accessible both nationally and internationally. At the national level, the country has as one of its goals to become "an informed and educated nation" (Republic of Botswana, 1997). The country cannot achieve this goal if it does not open up more learning opportunities for people. Internationally, the country cannot compete at this level without improving its global visibility. In 1999, the NCES statistical annual report stated that distance education offered through internet technologies was the fastest growing. Many other studies report a growing number of learners in distance education through online delivery. Ndahi (2006) says when faced with dwindling enrollment numbers in programs, it is important to seek alternative ways of delivering courses such as teaching through technology.

The use of technology in DE programs would also assist to enhance the quality of the programs, especially in the area of communication. The study reported that there was very minimal interaction between the tutors and the learners, even among the learners themselves. Use of communication tools such as Discussion Forums and Chats can greatly promote interactivity among the learners and make them feel part of a community. Feelings of isolation are some of the major down sides of distance learning has been appointed as the number one reason for drop outs (Rogers, 1990; Peters, 1992) and technology can assist to bridge this gap. In fact, Murphy (1995), says that in order to improve the quality of DE programs, four types of interaction are necessary: learner-content, learner-teacher, learner-learner and learner-interface. Instructional strategies need to indicate how the learner and tutor are going to interact and communicate. Approaches that

optimize communication are critical. Advocates believe that this helps to develop a unique one to one relationship between the tutor and the learner which is not even common in face to face classrooms.

The tutors in this study reported that the main reason they did not use technology to offer their courses was because they had learners in their classes who lived and worked in rural areas and they believed using technology would disadvantage these learners. However, in this study, it was found out that all the participants who lived in rural areas had access to computers and the internet and those who reported lack of access were those who lived in urban areas. In fact, it can be argued that this particular group of people, if need be, they can find access, as there are plenty of internet cafes in urban areas. This clearly shows that the non-use of technology was based on the assumption that the learners did not have access to technological resources, while the reality was that learners had access. However, it must be pointed out that this assumption was not far-fetched since generally, in Botswana, like in many other developing countries, there is, 'internal digital divide' whereby most technological facilities are concentrated in urban areas and rural areas are lagging behind, some lacking even basic services such as electricity. The government has a tendency to provide major technological developments in urban areas first and then slowly spread out to rural areas. See the ICT distribution model below:

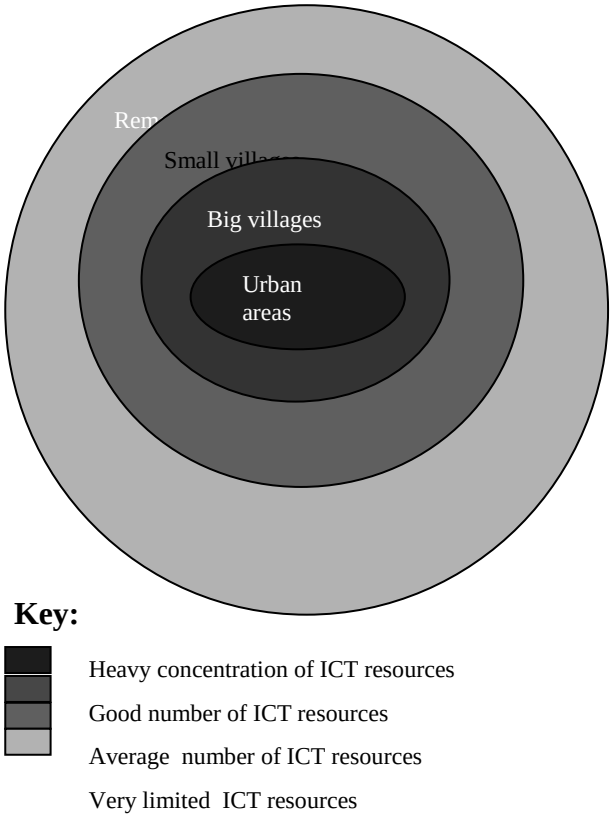

Figure 1; Typical ICT resources distribution model in Botswana

Scholars argue that digital divide is simply an exacerbation of pre-existing forms of inequalities or exclusion mainly social inequalities which are major characteristics of developing nations. Kelly-Salinas (2000), says that inequalities form a viscous circle whereby limited educational experience of parents has a negative influence on their children's academic performance, so this

cycle of deprivation continues. These groups of disadvantaged people are often found in certain parts of the countries which are remote and do not have many services found in urban areas and some distance learners live in these areas. According to the Survey of ICT and Education in Africa: Botswana Report (2007), Botswana is ranked 56th out of 115 countries on the World Economic Forum's network readiness index, but, there is a big difference in terms of urban and rural access to ICT resources (Isaacs, 2007). The country is faced with challenges such as high cost of computers and lack of electricity in rural areas. The country has liberalized its telecommunication industry so as to increase competition and the quality of services. However, the Government of Botswana alone cannot be blamed for the ICT disparities in the country as some of these developments are projects by private companies who decide where to implement their ICT projects and in most cases they choose urban areas because of the market since they are mostly profit making organizations.

Examples from places that have excelled in effectively using technology in their DE programs makes it clear that this task cannot be carried out by a single entity such as a university because the resource implications go way beyond the boundaries of institutions. As shown by the Australian DE system, this innovation needs full government support both in policy and finance. To its credit, the government of Botswana is currently working hard to eliminate the disparity in terms of access to ICT resources between urban and rural areas. This is being done through various initiatives and policies. These include projects such as Rural Telecommunications Initiative whose main aim is to ensure that more than 50% of Batswana living in remote areas of the country are provided with basic telecommunications services. There is the Community Information at the Touch of a Button which is made up of a network linking three rural villages to Gaborone (the capital city) to provide various services. Provision of all study centers and libraries with ICT resources so that learners anywhere in the country can have access. All these efforts are aimed at boosting ICT capacity in rural areas.

Conclusion and future research

Technology has the potential to greatly improve distance education in Botswana, therefore, UB has to take this matter seriously and embark on an initiative to incorporate technology in the delivery of its DE programs. All stakeholders should be involved in this process to ensure that there is sufficient support for the project. The university needs to benchmark especially with other institutions in developing areas to find out how they worked around issues of access (which is a common problem in developing countries) to use technology in their programs. A study needs to be carried out to find out why the declining enrollment numbers in DE programs at UB, so as to identify other factors that may be a stumbling block in the growth of the programs. Distance education as it is at UB faces a very bleak future and this paper argues that technology can breathe life into this seemingly dying process.

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