Information Systems Explorer — An Interactive Multimedia Teaching Support System for Information Systems Training

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Abstract

Information Systems Explorer (ISE) is a technology-supported learning research project conducted by the Multimedia Laboratory of the School of Business and Management at the Hong Kong University of Science and Technology. The aim of the project is to investigate the value of multimedia in supporting the teaching and learning processes for information systems training. This paper discusses the lessons learnt from the design and evaluation of the second generation of the ISE system (ISE II). The design philosophy of ISE II is to make use of interactive multimedia in providing a desktop virtual reality environment where students can learn about basic information systems concepts by navigating through a simulated office. The system allows students to interact with objects inside the virtual office, review the information associated with that object and respond to questions asked. Results of our initial evaluation indicate that the ISE II system has increased students' incentives and interests to learn. A key lesson learnt is that the effectiveness of the system will be greatly enhanced if a user is provided with a clear goal and an appropriate level of interactivity. Students were found to lose concentration and interest when the earlier versions of the system did not have built-in questions for obtaining instant feedback on the subject. The evaluation also reveals that the learning process will be greatly enhanced if the system design is learner-centred, i.e., it is designed around the end users' mental models based upon individual needs.

Introduction

Most of the current learning systems in the world are remarkably similar despite the cultural and geographical differences (Bork, 1991). They all tend to adopt an instructional approach, which is characterised by teacher-directed lectures and classes, supplemented by text books and notes. Verbal presentation by means of lecture and tutorial classes is supported by handouts and sometimes audio-visual media such as videos and slides. Presentation of the central theme of a subject is supplemented by case studies and examples. Many educators and business people find a shortcoming in this way of training as students are not necessarily able to relate the theoretical and factual contents of the subjects with real world situations. In general, the present teaching methodologies in primary, secondary and even tertiary educational institutions are primarily instructional-based; i.e., information is passed from teachers to learners through predominantly mono-directional communication. For example, a child does not learn how to walk by taking a walking class. As Schank (1994) argued, children learn by doing — in this case, by active participation in the walking exercise. The present teaching system has actually restrained students from active learning and has forced them into passivity.

The subject of information systems is not easily learnt through the traditional delivery methods. Information systems can be defined as a set of interrelated components working together to collect, retrieve, process, store and disseminate information for the purpose of facilitating planning, control, coordination and decision making in businesses and other organisations. An information system is 'multi-dimensional'. Other than the technology dimension, a learner also has to understand the dimensions of the organisation and the people. *Technology* is the means by which data are transformed and organised for business use. A computerised information system embraces hardware, software and telecommunication technologies. *Organisations* shape information systems in the form of the hierarchical structure that exists within a group of people, while procedures and rules govern how people perform in achieving the company's goals. Information is useful because *people* who use it find it useful. Moreover, the usefulness of information output from an information system relies on the input of data by people.

As such, rather than merely learning about computer systems, business information systems also entail an understanding of how businesses operate in the real world and how information technologies can be applied to solve business problems. Lacking hands-on experience on how businesses operate in the real world, the learning environment must not only allow the students to acquire the factual content of a subject, but also the broader knowledge needed to apply what they learned in different situations and in problem solving. Students must be trained to think critically and develop problem solving skills. To this end, it is argued that computer technology can help. As Button et al. (1992) cited, it is almost inconceivable in the 1990s to change teaching and learning methodologies without including the use of computers. Properly designed computer-based educational software has been viewed as supporting active participation and placing students in control. However, such software requires the adjustment of the present teaching architecture. Computer supported learning and training have been present for over three decades, from computer-based (CBT) training packages and simulation games, to the more recent learning tools on CD-ROMs. Despite the long history, Marchionini et al. (1995) argued that computer supported, let alone computer-based, techniques still played a very limited role in the overall picture of training and education.

The objective of the project is to design, develop and evaluate the effectiveness of an interactive multimedia learning environment in supporting the teaching and learning processes for information systems training. Although interactive multimedia has been applied in many educational software, little is known about the effectiveness of the design in enhancing students' learning abilities. Based on the lessons learnt and evaluation results of the first generation of Information Systems Explorer (ISE I) (Au and Choi, 1995; Au et al., 1996), we attempt to design a new generation of ISE that makes use of a virtual office interface. This paper discusses the lessons learnt from the design and evaluation of the second generation of the ISE system (ISE II) and the preliminary findings from the evaluation carried out.

Design of ISE II

The constructivist theory of learning , the scheme theory and the assimilation theory form the theoretical foundations of the design of ISEII. The constructivist approach to learning (Jonassen, 1991; Cobb et al., 1992) regards learning as the formation of mental models or 'constructs' of understanding by the learner. Under this approach, students actively build knowledge based on previous understandings through dynamic interaction with the learning media. The learner is able to control what to learn and at what pace. The success of learning relies on the interest, intelligence and ability of the learner to make decisions about lesson sequence, timing and emphasis. This approach also reflects a model of learning based on schema. In schema theory, learning is the accumulation and organisation of knowledge structures, which are representations of ideas in our semantic memory. Our knowledge is retained in a semantic memory which is a network of interrelated concepts. Each knowledge structure consists of an object as well as a set of attributes that are linked to other knowledge structures. Through the learning process, new links are formed and added to the existing structures.

The assimilation theory argues that in order to achieve meaningful learning, an individual must integrate new knowledge with existing knowledge retained in long term memory. To do this, however, the individual must first possess an appropriate assimilative context. Icon-based direct manipulation interface provides such an assimilative context by presenting subjects with an on-screen conceptual model, the advantages of which were reported elsewhere (Bayman and Mayer, 1983; Borgman, 1986; Mayer, 1981; Sein and Bostrom, 1989). It also allows users to work on-screen in a similar way to how they would in real life, thereby reducing users' cognitive processing load (Hutchins et al., 1986; Shneiderman, 1983).

As mentioned before, ISE II is the second generation of the Information System Explorer (ISE), a hypermedia-based interactive computer-aided desktop learning environment. Hypermedia is defined as a non-linear information database with a node and link structure allowing users to access text, images, sound and other media (Hooper, 1990). According to Kozma (1991) and Jonassen (1992), the hypermedia structure facilitates users to build links between objects as well as 'construct meanings based on these relationships'. Under this notion, the design philosophy of ISE II is to make use of interactive hypermedia in providing a desktop virtual reality environment where students can learn about the role of information systems by navigating and interacting in a simulated office. The system allows students to interact with objects in the virtual office and review the information associated with that object. The design of ISE II embodies constructivist theory as it is structured to allow a learner to take more control of the lessons. Apart from being provided with information in an interactive environment, students are also assigned to perform various tasks during each training session. These tasks focus on training the learners to apply information systems concepts in solving the business problems of the simulated company, thus further strengthening the notions of user-centred learning or 'learning by doing'.

In addition, we also designed the system with the following principles in mind (Nosal et al., 1995):

- Rigorous treatment of concepts and methods
- Emphasis on real world problem solving
- User friendliness in terms of user interface and navigation
- Ability to maintain attention by being entertaining.

The ISE II system was divided into four sessions — the first two sessions presented the virtual office developed using an artificial office model (see figure 1) generated by FormZ, while the other two sessions presented a real office setting using Apple Quicktime VR® (see figure 2). Development was mainly done on an Apple PowerMac 8500. Both systems were authored using Macromedia Director®, a cross-platform multimedia authoring tool for producing interactive presentations, CD-ROM titles, software demonstration and information kiosks.

Figure 1: Virtual office developed using an artificial office model

Figure 2: Virtual office generated using Apple QuickTime VR

Through mouse control, users were able to move around the office. Specific objects within the animated office were programmed to become hyperlinks to additional information — text, voice and movie. However, the degree of navigational freedom was constrained partly due to technical reasons (memory constraints) and partly due to the intention to test the effect of navigational freedom to users. In the virtual office environment, the participants were only able to access areas with hyperlinked objects. While Macromedia Director® was the main authoring tool, other software applications were used to enhance the media richness. Video footage was digitised and edited using Apple Quicktime® and played back via QuickTime® Player. Still images were enhanced using Adobe Photoshop.

Apple Quicktime VR® technology enables users to navigate, through mouse control, freely in a 3-D environment which closely resembles the real world. Similar to the virtual office created in Director®, users interacted with the system through various navigational aids — directional arrows for mouse, hot spots and buttons. The high degree of reality and freedom of movement provide users with a different experience. The Quicktime VR 'movie' was made up of a series of still photographic images taken systematically in a real office environment. The office can be divided into grids of equal size, with each intersection of the grid becoming a 'hot spot'. Using a camera stabilised on a tripod and revolving at the same spot, at least eight pictures were taken, capturing the entire 360 degrees surrounding the hot spot. The still pictures were then scanned, digitised and formed into a 3-D environment using Quicktime VR®. All areas / objects within the Quicktime VR environment are programmable to form hyperlinks to other 'documents', in various modes of representation, including Quicktime movies and animation played in a Macromedia Director environment. Users in a Quicktime VR environment enjoy a higher degree of navigational freedom. However, the degree of interactivity still depends on the richness of the 'clickable' objects.

Although both systems provided a hypermedia environment for browsing and navigation, the different level of navigational freedom and interactivity, as well as the degree of 'reality' of the two were perceived to have varied impacts to users. The four sessions were further supplemented by a fifth session which used the interactive multimedia document developed in ISE I (which presented the topic of Management Support Systems) to compare to the more media rich and interactive hypermedia environments in ISE II. The session on Management Support Systems was also developed in Macromedia Director® but was different from the virtual office environment in ISE II. The structure was more hypertext-like with interlinking by buttons. The major modes of representation were text and video.

System Evaluation Design

Nineteen first year students in the Department of Information and Systems Management of the Hong Kong University of Science and Technology were selected to participate in the experiment. All the participants were enrolled in the first year course, Introduction to Information Systems. First year students were selected as test subjects as they could safely be assumed to have had no prior formal knowledge about or exposure to the subject.

Cognitive styles can be defined as the characteristic, self-consistent modes of functioning which individuals demonstrate in their perceptual and intellectual activities (Witkin et al., 1971). Field dependence / field independence is a common measure of cognitive style. It indicates how well a learner is able to restructure information based on the use of salient cues and field arrangements (Weller et al., 1994). Past research results (e.g., Witkin et al., 1977; Carrier et al., 1984) suggested that the effective learning of field dependent learners dropped substantially in a less structured environment and when cues were not available. As such, field dependence / independence is perceived to have an important relationship with learning effectiveness, especially in a less structured hypermedia environment.

To measure the participants' cognitive style, each was asked to take part in a pre-test, the Group Embedded Figures Test (GEFT) published by Consulting Psychologists Press, Palo Alto, California (1971). The GEFT is widely used in a variety of research studies which require the assessment of cognitive style. In a GEFT, each participant is required to locate and trace simple forms hidden within complex figures in a limited period of time. The maximum score is 18, in which the higher the score, the greater the degree of field independence. For the purpose of this study, the participants could be classified into two groups based on GEFT scores. Those with a score greater than or equal to 12 are categorised as field independent, while those with less than 12 are field dependent.

In addition, the participants were also required to take another test to determine their learning styles. The Learning Style Inventory was therefore adopted. A Learning Style Questionnaire of 80 statements was answered by students by putting a tick if they agreed more than disagreed with a statement, and vice versa. The questionnaire measures preferences for four different ways of learning. The highest score in one particular way of learning signifies the student's preference of that learning style.

Activist

The score obtained in this preference indicates the degree to which one would prefer to work from the basis of practical experience, as they occur in the present.

Reflector

This preference relates to understanding information or events in a comparative calm and quiet environment. A person with a high score in this preference area will tend to work and adapt to new situations and information by taking time to reflect, gather information, test observations and think through their impressions.

Theorist

This style is concerned with forming abstract patterns with the information established by understanding events which have been experienced. Connections, correlation and concepts about the world can be established, providing the basis for planning how to react to the next situation.

Pragmatist

If a participant achieves a high score on this preference, he / she is likely to take risks, test his / her understanding and plan quite thoroughly in practice. This style is likely to generate significant responses in the world, providing some very noticeable concrete experiences. If some of the reflector and theorist skills are less developed, there could be a greater risk of failure.

It is perceived that the learning styles of individual participants might have some bearing on how effective or successful they would be in engaging in the hypermedia exploratory experience. By analysing the scores of participants with different learning styles, one can gain some insight in terms of their correlation.

The evaluation sessions took place in the University's Macintosh Computer Laboratory which was equipped with over 30 Apple Macintosh computers in a network environment. ISE II software was loaded onto each machine. The virtual office was featured in sessions 1 and 2, followed by the QuickTime VR environment in sessions 3 and 4. The hypermedia-based 'management support system' was used in session 5. The participants were required to attend all five sessions, each of which lasted for about 1 to 1.5 hours. They worked individually and at their own pace. Moreover, they were free to stop and leave the system at any time. Students were required to complete multiple choice questions which were based on the contents of the system that they just experienced. In sessions 2, 3 and 4, on-line built-in questions replaced the manual questionnaire used in the previous session to increase the interactivity. Both factual and applied questions were included and intended to test the participants' retention as well as analytical capabilities. The scores were analysed and means and standard deviations from each session were calculated. In addition, the keystrokes of each participant were recorded to track the route taken and the time spent in each mode. At the end of each session, each participant was also required to complete a user survey to solicit their views on the usefulness of the system.

Evaluation Results and Discussions

The effectiveness of knowledge acquisition is measured by the test scores yielded (as a proportion to full score). Results of the experiments are illustrated as follows:

	Virtual Office	MSS	QTVR
All			
Mean	0.54	0.54	0.62
Std dev	0.13	0.18	0.34

Virtual office: Virtual office environment built from graphics and animation in Macromedia Director.

MSS: Hypermedia presentation made up mainly of text and digitised video in Macromedia Director.

QTVR: Virtual office environment developed in Apple QuickTime VR with Director movies built in.

Overall, the participants obtained the best scores in the QuickTime VR environment. It was slightly surprising that they scored equally in the MSS session and in the virtual office environment which had a higher degree of interactivity. This is attributable partly to the fact that the participants are still more used to the more instructional text-based learning environment than the more constructive interactive learning system. While the mean test score in the QuickTime VR environment is the highest amongst the three different modes of representation, it also had the highest standard deviation, indicating a wider diversity of scores between individual participants. This is understandable due to the new environment that the participants were experiencing; some were more accustomed to it than others.

By looking at the interaction of the learner cognitive style and the modes of representation, results of the experiments indicated that field independent participants scored higher than their field dependent counterparts irrespective of the modes of representation. Again, standard deviation showed a wider spread of score in the QuickTime VR environment. The better performance of field independent users in the hypermedia computer environment was supported by previous study results (Weller et al., 1994). In line with the overall scores, the participants learnt best in the QuickTime VR environment. Field independent participants performed equally well in the Virtual Office and MSS, whilst field dependent participants actually fared better in the more text-book like MSS environment.

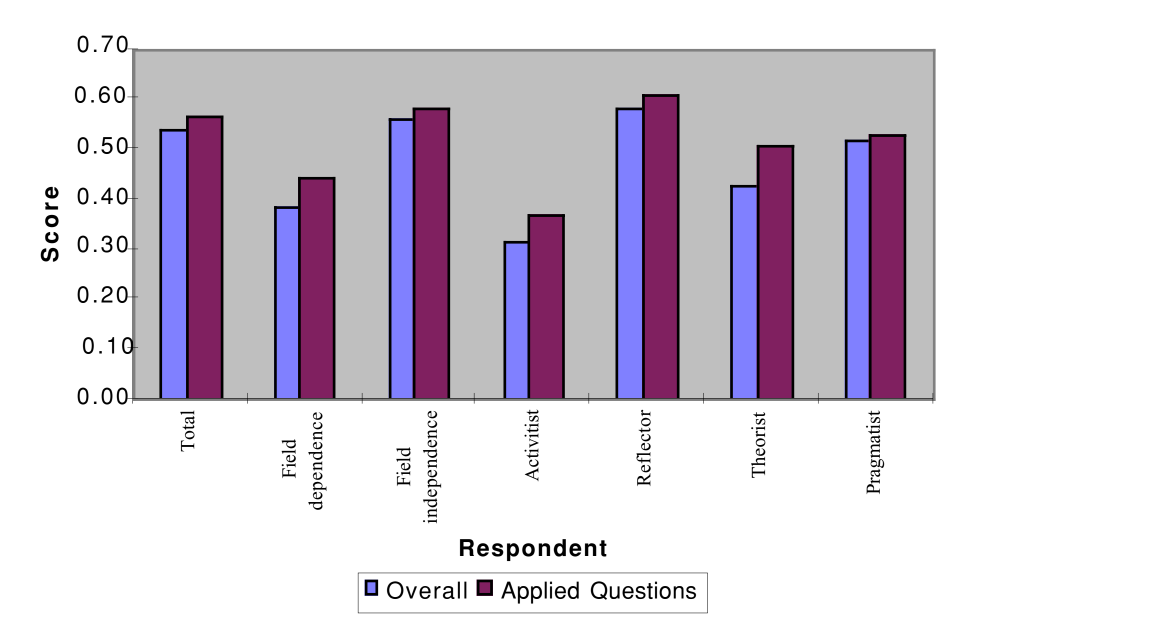
	Virtual Office	MSS	QTVR
GEFT			
Field dependence			
Mean	0.38	0.50	0.56
Std dev	0.14	0.14	0.41
Field independence			
Mean	0.56	0.55	0.63
Std dev	0.12	0.19	0.28

In addition, we also assessed the relationship between the participants' learning styles and learning performance. The results confirmed the QuickTime VR environment's conducive effects to the participants' knowledge acquisition. By definition, activists and pragmatists are more happy to explore and try out new ideas. On the other hand, reflectors and theorists tend to be more cautious in putting ideas into practice. Pragmatists and theorists were originally perceived to have performed better in the interactive learning environment. However, the test results indicated that this perception was less than conclusive. In general, reflectors yielded consistently high scores in all three modes of representation, out-scoring the pragmatists in all three categories. Results indicated that the activists are the poor performers. One possible explanation of these results is that the depth of hyperlinks (in our case, only two levels) is insufficient to unleash the full exploratory potential of the pragmatists, resulting in mixed results.

	Virtual Office	MSS	QTVR
Learning style			
Activist			
Mean	0.32	0.60	0.33
Std dev	0.12		0.19
Reflector			
Mean	0.58	0.60	0.60
Std dev	0.10	0.12	0.29
Theorist			
Mean	0.43	0.53	0.63
Std dev	0.18		0.24
Pragmatist			
Mean	0.52	0.47	0.57
Std dev	0.11	0.24	0.40

Some of the questions are not directly related to the factual information contained in the systems and require the respondents to apply the concepts embedded in the systems into different situations. The main purpose of these questions is to test the respondents' conceptual understanding of the subject matters. Analysis of the socres indicate that scores in these applied questions tend to be higher than the overall scores, irrespective of the respondents' learning styles or learning performance. This conclusion implies than the learning experience gained from interactivity has facilitated the respondents' conceptual understanding.

	Mean	Standard Deviation
Overall	0.57	0.18
GEFT		
Field dependence	0.44	0.14
Field Independence	0.58	0.18
Learning style		
Activist	0.37	0.05
Reflector	0.61	0.20
Theorist	0.51	0.13
Pragmatist	0.53	0.16



Analysis of the user surveys conducted at the end of each session have drawn the following observations. When comparing hypermedia with the traditional instructional media such as text books and lectures, the former was generally preferred. The participants all felt that ISE helped them understand the various concepts of the subject and was a good source of information for future reference. Participants all found the system quite easy and fun to use, and were particularly impressed with the animation. It was unanimously agreed upon that having questions and answers in the system was effective as the increased interactivity has made the system more fun to use and the participants' recollection of the contents improved through rehearsal.

On the other hand, the participants also highlighted some areas where improvements are required. Sound, in terms of both quality and speed of speech, was one area which definitely needs enhancing. Participants commented that the sound was sometimes inaudible and that the person spoke too fast. Some also found the background music too loud and distracting. These comments highlighted the importance of and the technical difficulties in adding sound into a multimedia system. Some participants suffered from information overload as they were overwhelmed by the wealth of information provided in the system, which they found difficult to absorb in a relatively short period of time. Instead of questions and answers, some suggested that increasing the tasks to be accomplished / decisions to be made would made the system even more fun to use. It was suggested that the learning experience would be further enhanced if, other than the correct answers, the built-in questions should also come with explanations if wrong answers were given.

Survey findings did not indicate any major preference between the Director® version and the Quicktime VR® version of the virtual office. They indicated that interactivity is generally preferred to linearity. However, the speed of animation in the former was so high that many of the participants claimed they could barely read the content and that little time was left to think about its meaning. One suggested solution was to allow the participants to control the speed. Some also complained of disorientation during browsing, indicating insufficient navigational aids in the system. On the other hand, in the Quicktime VR® version of the system, some participants found it hard to find the hot spots, partly because they had no prior knowledge of what needed to be found (number of hot spots) and partly because the participants had yet to become used to exploratory learning. In sum, the participants preferred the virtual office environment to the hyperdoucment, and in turn to text-based methods.

In terms of the hypermedia instructional system design, a few lessons were learnt. First, a good story or script is important to have prior to production. Like movie making, a good movie cannot be made without a good script. The second lesson is that immediate feedback and interaction built into the system is very important to have as well. Similar to computer games, the players' interests to continue playing can be maintained if they are immediately awarded for success.

Direction for Further Work

Marchionini et al. (1995) argued that the present limited use of computer-based learning and training is likely to change before the turn of the century. They argue that the critical success factor that can turn the tide will not be multimedia or the information superhighway, but the emergence of large digital libraries that will provide valuable background resources to both authors and learners. The ease of access and availability of information are phenomenal. At this juncture, computer supported collaborative learning (CSCL) is certainly an area where intensive research is required.

The success of the QuickTime VR environment in our experiment calls for further research in the development of virtual reality technology in the learning environment. A true virtual reality environment will allow users to learn by doing and making decisions on simulated events, and through interacting with co-users at the other side of the network or artificial agents immersed in simulated virtual space.

Artificial intelligence is an important research area for interactive learning systems because it will be able to modify the learning programme according to the needs and performance of a particular participant. As Chan and Maurer (1993) suggested, in addition to multiple learning cues received from different media, artificial intelligence can be used to improve search adaptability and flexibility for both individual and group learning.

Beside technological advancement, it is fundamental to further consolidate and confirm our understanding of the cognitive foundation of hypermedia / multimedia and its relationship with human cognition and behaviour. The future is likely to see the convergence of multimedia with other disciplines such as human-computer interaction and user interface design, as improving input and output technologies expand the potential for simulations using sophisticated perceptual-motor skills in addition to cognitive ones. Future research will witness the examination of other attributes such as the effects of different types of knowledge, the cognitive needs of the knowledge author and the knowledge learner's style of learning from technology-supported teaching.

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