BUILDING PATHOLOGY USING COMPUTERS – THE NEW PHENOMENON

MARK SHELBOURN, MIKE HOXLEY, GHASSAN AOUAD

Dr Mark Shelbourn – European Union Research Group – Department of Civil and Building Engineering - Loughborough University – Loughborough – LE11 4WG – UK.

Dr Mike Hoxley – Department of Built Environment, Anglia Polytechnic University, Chelmsford, CM1 1LL, UK

Prof. Ghassan Aouad – School of Construction and Property Management, University of Salford, Salford, M5 4WT, UK

Contact m.a.shelbourn@Lboro.ac.uk for more details

ABSTRACT

Building Surveying employers are requiring graduates with a high level of cognitive and experiential skills to enable them to survey buildings directly after graduation with little or no supervision. These skills have traditionally been built up over many years through on the job training. This has led to a change in thinking for educators as providing this type of graduate requires learning and training material that is time consuming and costly to provide, as it requires learners to be actively involved in real surveying tasks.

One method that appears to solve some of these problems is computer-aided-learning (CAL). CAL can be defined as, "…a way of presenting educational material to a learner by means of computer program which gives the opportunity for individual interaction." The full potential of CAL tools in the building-surveying domain has yet to be fully explored. This paper presents the results of a prototype application developed to enable inexperienced surveyors to learn building pathology without leaving their desktops.

KEYWORDS: BUILDING PATHOLOGY, INFORMATION TECHNOLOGY, COMPUTER-AIDED-LEARNING, SOFTWARE TESTING

INTRODUCTION

Online education has generated tremendous excitement both inside and outside higher education. For some, it offers the potential to provide learning to new audiences; for others, it offers the opportunity to fundamentally transform learning delivery and the competitive landscape. (Poehlein, 1996) Among those institutions with better-defined reasons for embracing online education the rationales vary, but they often fall into one of four broad categories:

1. Expanding access;
2. Alleviating capacity constraints;
3. Capitalising on emerging market opportunities;
4. Serving as a catalyst for institutional transformation. (Volery and Lord, 2000)

If universities want to take advantage of online education then it is essential to identify and understand the critical success factors affecting the online delivery of education. Indeed, if we continue to re-implement conventional models borrowed from classroom-based or distance education focused on passive transmission, we can expect only marginal improvements and may well simply escalate costs.

The e-learning marketplace is growing rapidly. For example, in May 2000, *Fortune Magazine* estimated that on-line learning will become a $22 billion market by 2003 (Morgan, 2001) and the estimates keep on rising. Research from IDC [an American Research firm] estimated that the US executive e-learning market alone will grow from less than $1 billion in 2001 to $7 billion in two years. (Morgan, 2001) Numerous companies are entering this space by converting old product offerings into new digital forms. If academic institutions wish to match their industrial competitors then more work needs to be undertaken to provide e-learning services.

Morgan (2001) states that there are thirteen 'must ask' questions that need to be asked about e-learning products and services. The questions are:

- What services does the e-learning supplier or application that you are considering actually provide?
- What type of instructional content is being supplied?
- How granular id the content?
- Is it possible to customise the product or service being offered?
- How flexible and focussed is the learning experience provided?
- How interactive is the learning system?
- Is the learning system intended to complement or replace face-to-face styles of education?
- Is the learning architecture open or closed?
- Does the system allow you to enrich learning through complex behavioural simulations?
- Does the desire to assess and evaluate learning dominate the learning process and end up getting in the way of real learning and the enthusiasm with which users will embrace the system?
- To what extent does the learning product or service result in the creation and sharing of new knowledge?
- How secure and confidential is the learning system?
- Is the learning system "second generation" and also positioned for "third generation" development? (Morgan, 2001)

These 13 questions, when properly answered, provide a solid basis for evaluating online learning and education products, and for positioning an organisation's approach to e-learning with an eye on the future instead of the past.

Some key factors at a much higher level than the 13 questions have been highlighted by Volery and Lord (2000). These should be used for effective online delivery of educational material.

EFFECTIVENESS OF ONLINE DELIVERY

Webster and Hackley (1997) remarked that students' performance, measured by their marks, represents a key aspect of teaching effectiveness. However several studies have shown that there is little or no difference in student performance between educational television and face-to-face instruction (Wetzel et al., 1994) or between video instruction and face-to-face instruction (Storck and Sproull, 1995). Webster and Hackley (1997) further suggested that the following dimensions can capture the concept of effectiveness: student involvement and participation, cognitive development, technology self efficiency [i.e. the belief that one has the capability to interact with a given technology], perceived usefulness of the technology employed, and the relative advantage of online delivery.

According to studies conducted by Dillon and Gunawardena (1995) and Leidner and Jarvenpaa (1993), three main variables effect the effectiveness of online delivery: technology; instructor characteristics; and student characteristics.

TECHNOLOGY

The reliability, quality and medium richness are key technological aspects to be considered (Sanders Lopez and Nagelhout, 1995). In particular, the network set-up should allow for both synchronous and asynchronous exchange; students should have convenient access [e.g. through a remote access]; and the network should require minimal time for document exchange. The quality of the interface also plays a critical role (Trevitt, 1995). The literature concerning interface design for online delivery ranges from the highly artistic (Laurel, 1990) too highly technical (Blattner and Dannenberg, 1992). Reeves and Harmon (1993) presented a synthesis between these two tendencies and identified the following dimensions as being important in the user interface: ease of use; navigation; cognitive load; mapping; screen design; information presentation; aesthetics; and overall functionality.

The perceived richness of the technology should also influence the effectiveness of online delivery. In medium richness theory (Daft and Lengel, 1986), a rich medium is one that allows for both synchronous and asynchronous communication and supports a variety of didactical elements [text, graphics, audio and video messages]. A central part of the medium richness relates to interactivity. Indeed, McIntyre and Wolff (1998) noted that "…*one of the powers of interactivity in a web environment is the capability to engage by providing rapid, compelling interaction and feedback to students.*" Engagement is also enhanced by problem-based presentation of educational material. An engaged student is a motivated student (Neorman and Spohrer, 1996)

INSTRUCTOR CHARACTERISTICS

Collis (1995) remarked that the instructor plays a central role in the effectiveness of online delivery: "…*it is not the technology but the instructional implementation of the technology that determines the effects on learning.*" Webster and Hackley (1997) suggested that three instructor characteristics influence learning outcomes; 1) attitude towards technology; 2) teaching style; and 3) control of technology.

Students attending a class with an instructor who has a positive attitude towards distributed learning and who promotes the technology are likely to experience more positive learning outcomes. In a distributed learning environment, students often feel isolated since they do not have the classroom environment in which to interact with the instructor (Serwatka, 1999). To overcome this feeling, instructors can provide various forms of office hours and methods of contacts for the students. Most importantly, the instructor should exhibit interactive teaching styles, encouraging interaction between the students and with the instructor. Students in Internet distance learning courses often face technical problems. It is therefore crucial that the instructor has a good control of the technology and is able to perform basic troubleshooting tasks [e.g. adding a student at the last minute, modifying students' passwords, changing the course settings]. Organisation skills go hand in hand with control of technology. Haynes et al. (1997) remarked that a designed instructor is essential for overall coordination and that, as the development of an online course is labour intensive, both faculty and technical resources must be identified and committed to the schedule at an early stage.

STUDENT CHARACTERISTICS

A variety of characteristics with potential influence on online delivery can be identified in the literature. As maintained by Colley et al. (1994), such variables as prior experience, having a computer at home, and personality produce gender differences towards computers. Reinen and Plomp (1993) found that computer usage at school was dominated by males in most of the 21 countries they surveyed. Computer experience is another variable which can have an interaction with gender (Kay, 1992).

In addition to gender, other demographic characteristics are likely to impact on the effectiveness of online delivery. It is anticipated that the programme in which the students are enrolled will play a role. The enrolment interacts with computer experience. Another demographic variable to be considered relates to the country of origin of the student.

Leidner and Jarvenpaa (1995) also suggested that students lacking the necessary basic skills and self-discipline might do better in a traditionally delivered mode. Similarly, the brightest and most motivated students may prefer to learn in an individual competitive environment rather than sharing their knowledge with less motivated, less bright students in a traditional classroom setting.

LEARNING IN BUILDING SURVEYING USING COMPUTERS

Using computers to train inexperienced building surveyors is a relatively new idea. Researchers considering using computers to train surveyors include Mika (1999 & 2000), Parnham and Middleton (2000) and Shelbourn et al. (2000).

Much work has been carried out to provide a surveyor with a procedural framework to adhere to when undertaking a survey. Authorities differ on the question of whether it is better to commence the full inspection internally or externally. Many suggest that it is better to inspect internally initially, as this will cause the least convenience to the occupier (Melville et al., 1992), while others seem to suggest that commencing with an external inspection follows more logically the order in which it is usual to report (Hollis, 2000). Hoxley (2002) suggests that "…*in many respects the order of inspection is a matter of the personal preference of the surveyor but what is most important is that the inspection is carried out in a logical sequence with which the surveyor is familiar*." This is applicable for a surveyor who has gained enough experience to be able to recognise what there individual 'logical sequence' is.

However for a younger, more inexperienced surveyor this may prove difficult. The ability of a computer to simulate the experiences of a number of experienced surveyors to enable a computer-aided-learning tool to be developed could provide a means for younger surveyors to learn how to undertake a survey in a residential building. In an editorial in the "*Structural Survey*" journal Hoxley (1996) describes a scenario that hypothesised this theory. Other researchers have had their own thoughts on using computers to train inexperienced surveyors.

This article was not that futuristic as other authors were also considering technology as a tool to aid education. Kane (1997) reviewed the changing role of the field computer in the surveying profession and addressed the primary uses and requirements of portable IT in geotechnical applications. Kane also described the growing trend towards Global-Positioning-Systems [GPS] and concluded with a prediction of the design of the surveyors' mobile computer in the new millennium. His conclusions were realistic in their proposal, but unfortunately the increased use of GPS systems that Kane foresaw has yet to be realised. This maybe due to the cost of getting information to field handheld systems using the WAP technology now developed. What Kane envisaged is becoming more standard, but for the smaller practise the more traditional methods will be used for a few years yet, as they will need to be reassured by larger organisations proving that the cost and time investments in this new technology will be beneficial to them.

Paterson et al. (1997) conducted research showing how computer vision has the potential to improve the exterior inspection of large buildings. A robot was developed that could perform a number of tests, with the computer vision used to locate the robot and thus the defects.

Perhaps the answer lies in the research conducted by de Boehmler (1998), Coday and Hoxley (2001). These pieces of research show that realistic data entry and data handling is the key to unlocking the power of modern computer tools for all forms of building management functions. A survey system is needed to get the vital data about a property collected and entered into any management database. Three discrete usage areas for computer technology are identified: data collection, manipulation and presentation. The key differences between the various types of building survey are outlined. The conceptual and actual challenges in each survey system are explored. Past problems and mistakes in applying technology are discussed. Innovative automated, efficient, and integrated solutions are suggested. A new multimedia and completely digital approach is recommended for applying new computer-based tools to all kinds of property inspection. The future tools for super-efficient building surveys for the 21st century are considered and predicted.

This article outlines some of the ways in which technology could reduce the amount of mistakes being made by inexperienced surveyors. However, the actual knowledge needed to add information into a system still needs to be acquired by an inexperienced surveyor. The use of technology is only a prompt for information; the skills need to be learnt and developed in other ways.

After many false dawns, computer processing power and software development have now reached a stage when one can clearly see that Information Technology (IT) can play a significant role in the work of construction and property professionals. An article written as far back as 1993/4 by Scott et al (1993/4) highlighted this revolution in computer technology and conducted a survey demonstrating the use of computers in the construction industry. Whilst computers can take much of the drudgery out of some of the technical work required to plan buildings, (Marir et al. 1998) they will never be able to inspect buildings. Any person who watched the Channel 4 "*Dispatches*" programme "*Surveying the Surveyors*" on 25th February 1999 will have been severely depressed by the poor level of competence demonstrated by ten randomly selected house surveyors. The programme was based on work carried out by Hollis and Bright (1999). This research examined the perceived concern in the public arena about the quality of residential surveys and suggests a high rate of sub-standard reporting within residential surveys. The Homebuyer form of report was used in a test of survey standards. A sample of ten surveyors examined the same house in controlled circumstances. Only one surveyor identified each of the three key defects within the property. The research considers the method of assessment of quality within surveys and reports upon the identification of defects and the levels of recognition. The overall picture portrayed from the results suggests a failure rate of 90%. Taking the most favourable approach to the findings it could be argued that just 20% of the reports were adequate. It is suggested that at least 60% of the survey reports failed to reach an adequate standard. The variation acceptability depends upon the evaluation of the report provided by each surveyor. Whichever way the results are viewed it does not paint a healthy picture of the building surveying profession. The research concluded that there is an unexpectedly high level of reporting that falls below an acceptable standard. Recommendations are made for the improvement of standards, an assessment of the skills required and the requirements for the education process for surveyors.

The research continued with Hollis (1999) publishing a paper entitled "*Survey of surveys: dampness*" in which he took the findings of the previous research and developed a sub-set of work that dealt with the public perception of survey standards relating to dampness, the duties of the surveyor, and the knowledge requirement for a surveyor working in 1999. The research looked at the observation and the reporting of dampness within a sample of ten survey reports completed within a period of two weeks on the same house. The research concluded that there is an unexpectedly high level of reporting that falls below an acceptable standard. Recommendations were made for the improvement of standards; an assessment of the skills required and the requirements for the education process for surveyors was also highlighted.

As more and more information was collated the research continued at pace. In early 2000 Hollis (2000a) looked at the analysis of the methodology of inspection of parts of two buildings. The research looked at the observation process of inspection undertaken by a sample of 6 surveyors. This showed that parts of the exposed interior of the building were not being looked at. The time for the examination of a room was created by tests to set a model against which the inspections could be measured. The conclusion of this was that the inspection might be only 10% of that anticipated. This type of research into how long a surveyor should spend on a survey was also interesting to Mika (2001). Mika's research examined the time it took surveyors to complete a RICS/ISVA Homebuyer Survey and Valuation survey. Over 650 surveyors (94% response rate) completed datasheets on how long they spent at a site, dictating and finally checking a Homebuyers' report on four property types. The sample for the research represented over 45% of those professionals that carried out Homebuyers' reports. The sample was drawn from organisations varying in size from large corporates to sole practitioner firms. The results of this research were compared to previous work carried out by Hollis and Bright (1999) discussed above. The method of standard reporting was considered, and the absence of linkage between evidence collated for reporting in various compartments noted. The conclusions at that interim stage suggested that there should be a better-documented catalogue of the inspection process and that there should be a greater emphasis placed upon the contemplation of the implication of the evidence. The conclusions were based upon a very small sample, and this meant that the results might not be conclusive.

Hollis was not the only researcher that recognised there was a need for better training of inexperienced surveyors. Parnham and Middleton (2000) also recognised this lack of training and produced a piece of training material called "*Property Explorer*". The application was a computer-aided learning package developed to be a multimedia teaching resource. The property explorer application models a three-bedroomed terraced house with students having the ability to interact with the model and simulate a building survey. The use of multimedia as a training resource for construction has been discussed by Shelbourn et al (2001). In this article the authors showed how construction could learn from other industries, mainly manufacturing and engineering, in how to develop multimedia-training applications.

Shelbourn et al. (2000) developed a CAL tool using Virtual Reality techniques to portray defects in roofspaces of buildings. The next sections will describe some of the findings from the completion of the current work.

RESULTS OF CAL IN BUILDING PATHOLOGY TOOL

In order to test the usefulness and technical achievements of the prototype application a questionnaire was devised. The questionnaire was designed using the methods outlined by De-Vaus (2001). The questionnaire consists of 13 questions covering two A4 sides of paper, and split into two different sections. The first section asked the user groups' seven questions that elicited answers about the use of the prototype application. The second part of the questionnaire asked the users six questions about the actual content of the prototype, and the relevance to learning building pathology via a CAL application.

The main planning aspect of the test was to find the people willing to participate in the testing of the application. During the development of the application letters were sent to some of the surveying practices asking whether they wanted to participate in the project. A limited number of responses were received from these requests. When the testing strategy was being planned local surveyors were once again contacted by telephone to determine whether they wanted to test the application developed. Out of a total of 35 surveyors contacted within the Greater Manchester area, 10 agreed to participate in the tests. This meant that in order to obtain meaningful results 10 students were needed to test the application also.

The tests were designed to last between 30 and 60 minutes dependent on the interest of the person carrying out the test. The tester was sat down in front of the PC and given the application to use. Whilst the user was testing the application the questions from the questionnaire were asked at the relevant time during the test, so as to not distract the user from the testing of the application. This process was repeated for both the surveyors and the students testing strategies.

The testing of the application with the surveyors was carried out during a two-week period. The tests involved the author visiting the relevant company with a laptop computer with the prototype CAL application installed on it. The author visited the offices of the surveyors as it was seen as the professional thing to do, and to cause as little inconvenience to them as possible as it was the surveyors that were giving up their time to aid in the validation of the application and the thesis results.

The students who tested the application visited the offices of the author where they tested the application at various times during another two-week period.

In order to evaluate the tests carried out with the surveyors and the students of the usefulness of the CAL application each question of the questionnaire was taken and the responses to that question compared. The evaluation of the questions involved the comparison of the answers given. The options that the testers had to choose from ranged from 'strongly agree' to 'strongly disagree' with three other options between these two extremes. After the 'strongly agree' came 'agree' with 'neutral' being the middle answer, and finally 'disagree' coming between 'neutral' and 'strongly disagree'.

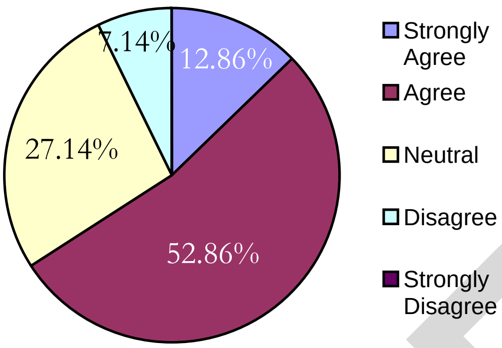
As there were 20 testers split 50:50 between surveyors and students, the results of the questions were displayed as a % of the total in the following tables and displayed graphically in the pie chart format. By comparing the results given by the surveyors and students to the questions of the usefulness of the CAL application to enable learning in building pathology opinions can be gauged to the success of such an application in a computer-aided-learning environment.

Having looked at the comparison between the results given to the 13 questions in the questionnaire, the next stage is to gauge the overall opinions of the students and the surveyors in the usefulness of the CAL application in the learning of building pathology.

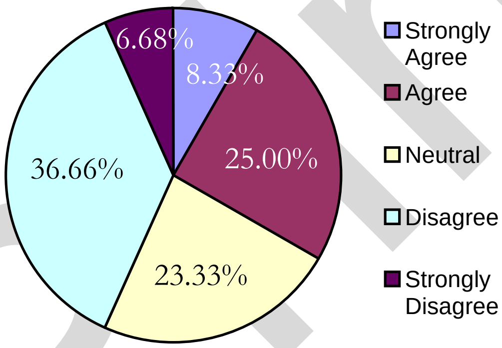
In order to do this the results from the questionnaires need to be collated and overall opinion determined. The way that this is done is taking the results from the two parts of the questionnaire and collating the results together. The first section will determine the technical evaluation of the application, with questions 1,2,3,4,5,7, and 8 being included in this analysis, and the remaining questions 6,9,10,11,12, and 13 being included as the usefulness of this type of CAL application. The results of this analysis are shown below. They show the results of the students and surveyors to determine whether or not this type of application is useful in the training of inexperienced of building surveyors.

STUDENTS RESULTS

SECTION 1

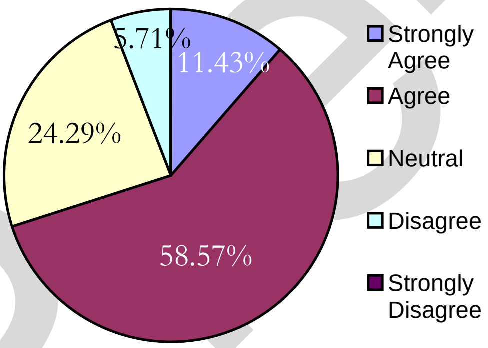


SECTION 2

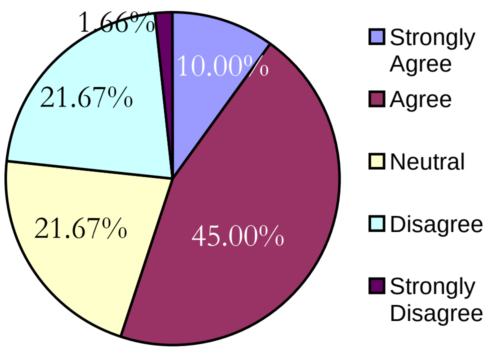


SURVEYORS RESULTS

SECTION 1



SECTION 2



In order to draw some conclusions from these results the two sets of results were averaged and look like this.

From figure 1 we can conclude that both the students and the surveyors agreed that this type of CAL application has few technical problems to aid the inexperienced surveyor in training. The results indicate that over two thirds of respondents tended to agree, with 12.15% of results strongly agreeing, and 55.71% agreeing. In this section (1) of the questionnaire just over one quarter (25%) neither agreed or disagreed that this type of application could help in the training of inexperienced building surveyors. There were only 6.43% of the questionnaire respondents that actually disagreed with any of the technical aspects of the CAL application. Out of all the respondents in section 1 74.29% of the results were given either as a strongly agree, agree, disagree or strongly disagree, in other words a definite answer to the question which means that it was easier to determine conclusions from the results.

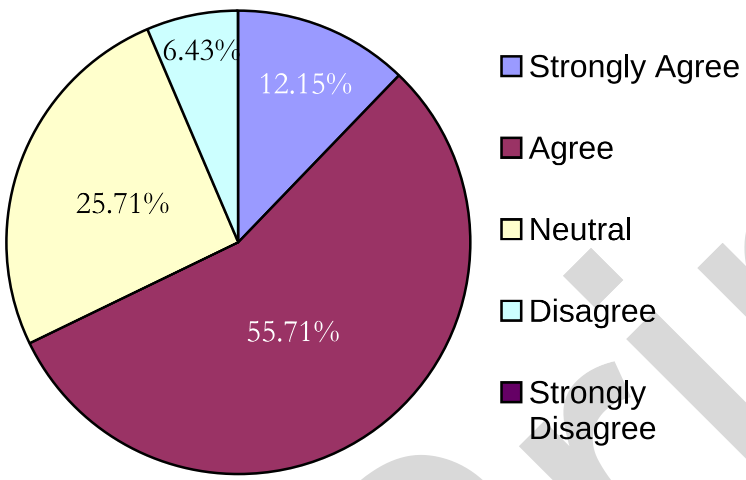


Figure 1: Pie chart of the combined overall results from the students and surveyors who took part in the questionnaire – section 1

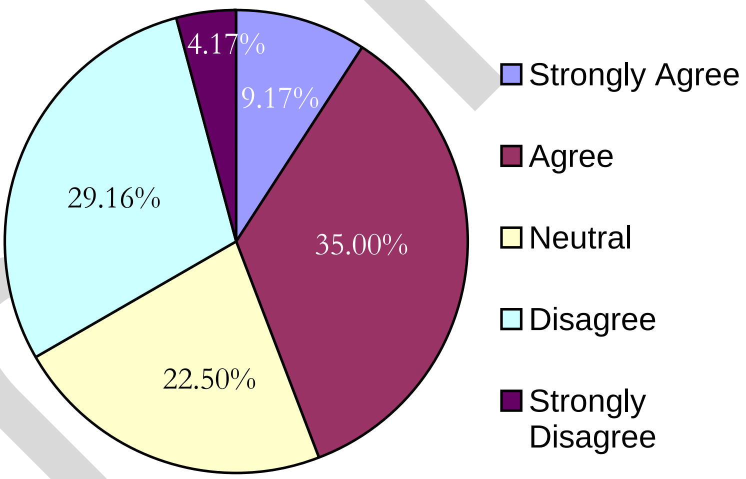


Figure 2: Pie chart of the combined overall results from the students and surveyors who took part in the questionnaire – section 2

Similarly, figure 2 above shows a similar picture to the usefulness of the CAL application in training inexperienced building surveyors. The actual percentage of answers obtained was a similar value 77.5%, showing a strongly agree, agree, disagree or strongly disagree response. From this 44.17% of the respondents were in the positive band and the remaining 33.33% were in the negative band. This shows that although the respondents generally agreed, there is a smaller % between the differences of the two percentages, which means that the respondents' results were not over concluding. The students did not agree that a CAL application of this type has the ability to provide a learning experience to enable them to learn about building pathology. Only 33.33% of students agreed, with 43.34% disagreeing and 23.33% not being able to decide. The surveyors results on the other hand show a different picture, with 55% agreeing, and only 23.33% disagreeing, leaving 21.33% not being able to decide. Results of this type may be explained by:

- Many students may not have been exposed to this type of application before which is likely to make them sceptical of such applications;
- As surveyors have much more experience within the domain they can easily recognise that this type of application could be beneficial to a surveyor;
- A surveyor may also recommend this type of application as they do not want the responsibility, or are aggrieved at having an inexperienced surveyor looking over their shoulder, watching and questioning their every move.

CONCLUSIONS

This paper has highlighted some of the issues associated with the online delivery of educational material. It has specifically outlined some of the reasons for organisations to participate in online education as being: expanding access; alleviating capacity constraints; capitalising on emerging market opportunities; and serving as a catalyst for institutional transformation.

The effectiveness of online delivery was then discussed. In this section 3 areas were highlighted as being important from the literature. These were: technology; instructor characteristics; and student characteristics. Many of these issues were then related to aspects of computers and education, particularly computer-aided-learning tools for the building-surveying sector.

A description of some of the main research that is, and has been carried out in the field of CAL in the building-surveying sector was described. This included specifically the work of researchers at Reading University, Sheffield Hallam University, and Salford University, plus any other individual research being highlighted where appropriate. As part of this section of the paper the results from the authors' research was specifically discussed. This included the methodology for testing the developed CAL tool and the graphical representations of the results being included.

The main conclusions to be drawn from the results of the research were that the overall technical aspect of the application was good. In terms of the appropriateness of a CAL application for the training of inexperienced surveyors there was a different opinion formed between the surveyors and students chosen. There does not seem to be a right or wrong answer to the question of appropriateness, rather the students were not as keen about this type of application as a learning tool, whereas the surveyors seemed to think that the tool was appropriate for inexperienced surveyors to learn. These were the main findings from the results of the questionnaire.

ACKNOWLEDGEMENT

The research was funded by an Engineering & Physical Sciences Research Council (EPSRC) PhD studentship at the University of Salford. Mark Shelbourn gratefully acknowledges the advice given to him by many people including, in particular, the research supervisors Ghassan Aouad of Salford University and Mike Hoxley at Anglia Polytechnic University, and invaluable input from Stephen Mika of the University of Reading and Phil Parnham of Sheffield Hallam University.

REFERENCES

Blattner, M.M. and Dannenberg, R.B. (1992) *Multimedia Interface Design*, ACM Press, New York, NY;

Coday, A., and Hoxley, M. (2001) "The portable test equipment being used for commercial building surveys", *Structural Survey*, Vol.19, No.4, pp.173-184, MCB University Press, ISSN 0263-080X;

Colley, A.M., Gale, M.T. and Harris, T.A. (1994) *Developing Lifelong Learners through Undergraduate Education*, National Board of Employment, Education and Training, Australian Government Publishing Service, Canberra;

Collis, B. (1995) "Anticipating the impact of multimedia in education: lessons from the literature", *Computers in Adult Education and Training*, Vol.2, No.2, pp.136-149;

Daft, R.L. and Lengel, R.H. (1986) "A proposed integration among organisational information requirements, media richness, and structural design", *Management Science*, No.32, pp.554-571;

de Boehmler, R. (1998) "Fully digital survey systems for property", *Structural Survey*, Vol.16, No.2, pp.61-66, MCB University Press, ISSN 0263-080X;

de-Vaus, D.A., (2001) *Research design in social research*, London: Sage;

Dillon, C.L. and Gunawardena, C.N. (1995) "A framework for the evaluation of telecommunications-based distance education", in Stewart, D. (Ed.) *Selected papers from the 17th Congress of the International Council for Distance Education*, Vol.2, Open University, Milton Keynes, pp.348-351;

Haynes, R.M., Pouraghabagher, R. and Seu, A. (1997) "Interactive distance education alliance (IDEA): collaborative model delivers on demand", *The Journal: Technological Horizons in Education*, Vol.24, No.8, pp.60-63;

Hollis, M. (1999) "Survey of surveys: dampness", *Structural Survey*, Vol.17, No.3, pp.138-142, MCB University Press, ISSN 0263-080X;

Hollis, M. and Bright, K. (1999) "Surveying the surveyors", *Structural Survey*, Vol.17, No.2, pp.65-73, MCB University Press, ISSN 0263-080X;

Hollis, M. (2000) *Surveying Buildings*, RICS Books, Coventry;

Hollis, M. (2000a) "The missing link", *Structural Survey*, Vol.18, No.1, pp.22-27, MCB University Press, ISSN 0263-080X;

Hoxley, M. (1996) "The virtual survey?", *Structural Survey*, Vol.14, No.4, editorial, MCB University Press, ISSN 0263-080X;

Hoxley, M. (2002) "Condition inspections of residential property: a procedural framework", *Structural Survey*, Vol.20, No.1, pp.31-35, MCB University Press, ISSN 0263-080X;

Kane, T. (1997) "The impact and changing role of the field computer within the surveying profession", *Structural Survey*, Vol.15, No.4, pp.148-150, MCB University Press, ISSN 0263-080X;

Kay, R. (1992) "An analysis of methods used to examine gender differences in computer-related behaviour", *Journal of Educational Computing Research*, No.8, pp.277-290;

Laurel, B. (1990) *The Art of Human-Computer Interface Design*, Addison-Wesley, Reading, MA.;

Leidner, D.E., and Jarvenpaa, S.L. (1993) "The information age confronts education: case studies on electronic classroom", *Information Systems Research*, No.4, pp.24-54;

Leidner, D.E., and Jarvenpaa, S.L. (1995) "The use of information technology to enhance management school education: a theoretical view", *MIS Quarterly*, Vol.19, No.3, pp.265-291;

Marir, F., Aouad, G., Child, T. and Brandon, P. (1998) "OSCONCAD: a model based CAD system integrated with computer related construction applications", *ITcon The Electronic Journal*, 3, http://itcon.org;

McIntyre, D.R. and Wolff, F.G. (1998) "An experiment with WWW interactive learning in university education", *Computers and Education*, No.31, pp.255-264;

Melville, I., Gordon, I. And Murrells, P. (1992) "Structural Surveys of Dwelling Houses" *Estates Gazette*, London;

Mika, S. (1999) "Computer-Assisted Learning in Building Surveying education", *RICS Research publication*, June 1999, ISBN No. 0-85406-957-7;

Mika, S. (2000) "Accrediting the surveyors", *Structural Survey*, Vol.18, No.2, pp.105-110, MCB University Press, ISSN 0263-080x;

Mika, S. (2001) "The Homebuyers' Report and Valuation – how long should it take?", *Structural Survey*, Vol.19, No.1, pp.21-26, MCB University Press, ISSN 0263-080X;

Morgan, G. (2001) "Thirteen 'must ask' questions about e-learning products and services", The Learning Organisation, Vol.8 No.5, pp.203-210, MCB University Press, ISSN 0969-6474;

Neorman, D.A. and Spohrer, J.C. (1996) "Learner-centered education", *Communications of the ACM*, Vol.39, No.4, pp.15-22;

Parnham, P. and Middleton, A. (2000) "Property Explorer – a guided tour of a virtual house", *Structural Survey*, Vol.18, No.4, pp.163-167, MCB University Press, ISSN 0263-080X;

Paterson, A.M., Dowling, G.R. and Chamberlain, D.A. (1997) "Building Inspection – can computer vision help?", *Automation in Construction*, No.7, 1997, pp.13-20, ISSN 0926-5805;

Poehlein, G.W. (1996) "Universities and information technologies for instructional programmes: issues and potential impacts", *Technology Analysis & Strategic Management*, Vol.8, No.3, pp.283-290;

Reeves, T.C. and Harmon, S.W. (1993) "Systematic evaluation procedures for instructional hypermedia/multimedia", paper presented at the Annual Meeting of the American Educational Research Association, Atlanta, April 14;

Reinen, I.J. and Plomp, T. (1993) "Some gender issues in educational computer use: results of international comparative survey", *Computer in Education*, Vol.20, No.4, pp.353-365;

Sanders Lopez, E. and Nagelhout, E. (1995) "Building a model for distance collaboration in the computer-assisted business communication classroom", Business Communication Quarterly, Vol.58, No.2, pp.15-22;

Serwatka, J.A. (1999) "Internet distance learning: how do I put my course on the web?" *The Journal: Technological Horizons in Education*, Vol.26, No.10, pp.71-76;

Scott, N., Ponniah, D. and Saud, B. (1993/4) "Computing and the Construction Industry", *Structural Survey*, Vol.12, No.4, pp.10-14; MCB University Press, ISSN 0263-080X;

Shelbourn, M., Aouad, G. and Hoxley, M. (2000) "Learning Building Pathology using computers – a prototype application" *Structural Survey*, Vol.18, No.2, pp.111-119; MCB University Press, ISSN 0263-080X;

Shelbourn, M., Aouad, G. and Hoxley, M. (2001) "Multimedia in construction education: new dimensions", *Automation in Construction*, Vol.10, pp.265-274;

Storck, J. and Sproull, L. (1995) "*Through a glass darkly – what people learn in videoconferences?*", Human Communication Research, No.22, pp.197-219;

Trevitt, C. (1995) "Interactive multimedia in teaching and learning: some pointers to help promote discussion of design criteria", paper presented at the Computers in University Biological Education Virtual Conference, CITI Liverpool, 30th January-10th February;

Volery, T. and Lord, D. (2000) "Critical success factors in online education", *The International Journal of Educational Management*, Vol.14, No.5, pp.216-223;

Webster, J. and Hackley, P. (1997) "Teaching effectiveness in technology-mediated distance learning", *Academy of Management Journal*, Vol.40, No.6, pp.1282-1309;

Wetzel, C.D., Radtke, P.H. and Stern, H.W. (1994) *Instructional Effectiveness of Video Media*, Lawrence Erlbaum, Hillside, IL.;