

ARTICLE

Using E-learning to Deliver Construction Technology for Undergraduate Students

A Case Study in Hong Kong

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Abstract

E-learning is an essential part of innovative, life-long learning opportunities for the 21st century. Many tertiary education institutions are developing an ever-increasing number of online programmes using advanced information and communications technologies (ICT). However, the benefits are not always an improvement over traditional modes of learning. This paper introduces the findings of a recent survey, which aims to investigate the feasibility of using ICT to deliver the subject of construction technology to undergraduate students. The paper provides a holistic view of the feasibility, effectiveness, efficiency and potential benefits of applying e-learning to construction technology. The findings show that e-learning is considered to be a practical method to study undergraduate construction technology. It is useful to help the students improve learning independence, learning efficiency and, to a certain extent, learning effectiveness. E-learning is particularly useful for part-time students compared with full-time, due to differences in learning characteristics and requirements. Nevertheless, these improvements would not necessarily result in achieving a better examination result in the subject. Significantly, the findings reveal that the single mode of face-to-face learning is preferred to the e-learning mode for delivering the subject of construction technology. In addition, the benefits of ICT may not be fully exploited.

■ **Keywords** – E-learning; construction technology; undergraduates; Hong Kong

INTRODUCTION

The advent of the Internet over a decade ago heralded the beginning of the online teaching and learning era. Online programmes are now regarded as the future direction of innovative, life-long learning opportunities for the 21st century and tertiary education institutions are developing an ever-increasing number of online programmes using advanced information and network technologies (ICT). According to *Peterson's Guide to US Colleges* on the Internet (Peterson's, 2005) in 1999 nearly 400 accredited colleges and universities in the US offered full online study programmes or used ICT to supplement

the traditional mode of classroom instruction. In the South East Asian region, The Hong Kong Polytechnic University took a lead in 2000 by offering an MSc/PgD programme in Project Management through its associate The Hong Kong CyberU. This was an online mode that offered students an innovative and flexible learning environment.

The asynchronous nature of distance learning programmes, together with the flexibility that they offer, is an obvious advantage to students. This is particularly so for students who may find it difficult to attend conventional taught classes either because of time or proximity constraints e.g. shift workers, those who reside in remote areas, and those who often have overseas assignments. This is particularly relevant in the case of

the Project Management programme, since it is focused on construction industry participants, many of whom move around from project to project. A study conducted by Mackerron (1984) revealed that the flexibility of time and place of study offered by distance learning was the main reason for students choosing this mode of study. Eastmond (1995) offered similar findings and stressed that most students chose the distance education option because of 'its convenience, its fit with their preferred learning style, and its ability to allow for selective anonymity during learning'.

However, the advantages offered by traditional distance learning are not without limitations: the separation of instructors and students in time and location can limit two-way communication; interaction between students and instructors may be minimal; and it is difficult to achieve group learning because students are largely taught as individuals and learn in isolation (Barker *et al*, 1989; Eastmond, 1995). Online technology goes some way towards addressing these issues by enabling students and instructors to carry out discussions at any time during the instructional process. For example, video conferencing is a useful tool to enable a group of students from multiple sites to participate concurrently in a structured tutorial with their tutor. A number of online education programmes have been developed using such advanced information and network technology (Hodson *et al*, 2001; Yazon *et al*, 2002; Yu and Yu, 2002).

With the proliferation of online programmes comes the inevitable question of quality and comparisons with traditional methods of teaching and learning. Many studies have been conducted to investigate the effectiveness of online teaching and have confirmed that the learning of online students is equal to the learning of classroom students (Gubernick and Ebeling, 1997; Schulman and Sims, 1999; Hodson *et al*, 2001; Zou *et al*, 2003). Starr (1998) found that interactivity is critical to the success of distance education systems, meaning that students and tutors can contact one another at any time of the day or night to share observations, information and expertise. She further suggested that a number of other issues need to be considered, including identification of educational needs and trends, instructional design philosophies and practices, and educational technology.

To address these issues, instructional designers and curriculum developers must examine learner characteristics and needs, the influence of media on the instructional process, equity of access to interactive delivery systems, and the teacher's role as the facilitator in the distance learning process. Mason (1990) highlighted student passivity as a major hurdle for effective education and Sheets (1992) suggested that learners are sometimes overly reliant on instructors. The geographical separation of instructor and students in distance learning requires even higher levels of self-discipline and independence on the part of students. Smith (1982) proposed that in designing programmes for distance learners, emphasis must be on:

- increasing students' self-awareness and capacity for self-monitoring and reflection when engaged in educational activity
- helping students to become more active learners and to assume an appropriate amount of control of learning-related activities
- broadening the individual's repertoire of learning strategies; and
- enhancing learner confidence and motivation.

A study conducted by Gal-Ezer and Lupo (2002) lends support to the above proposals by suggesting that using the Web to its full pedagogical potential requires a high level of self-study ability from the students. They also suggested that the more that distance-based learning is used as a medium of education, the more the Web will be used and accepted by students, and the more it will serve as a major communication channel and as a study tool.

With regard to instructional design, the constructive learning approach, in which a learner actively constructs an internal representation of knowledge by interacting with the materials to be learned, is considered an appropriate model for the design of online programmes (Hodson *et al*, 2001). Instructional designers should use empirical knowledge to state the objects, events and practices that mirror the daily environment of their designated learners, and then construct a situation that enables learners to obtain new knowledge by interacting with the instructional material.

As the relationship between the instructor and the students is a key ingredient to any successful distance

education programme, in order to make online programmes a success, it is essential to use advanced technologies and appropriate systems to provide a more personalized tutorial system. The use of computer-mediated conferencing encourages direct and personal contact between instructor and students, and between the students themselves; in such an environment, both instructor and students seek to recreate the classroom environment with which they are familiar. The advantages of computer-mediated tutorials are increased reflection, collaborative learning and intellectual amplification. However, its success is largely dependent on, first, the individuals who meet in this 'electronic classroom', second, the instructor's approach to teaching and, third, the communication pattern structured in the tutorial.

As a way of cultivating online two-way communication, the pedagogical design of programmes must allow for informal cross-student support for peer communications and also provide a means of instant feedback to all participants. The use of online chat rooms can bring students from different geographical regions together for informal discussions, and encourages them to interact with each other online; this is especially important for those who feel intellectually isolated. As for the provision of instant feedback, one of the most accessible and convenient computer-mediated communication channels for providing students with this is e-mail. Yu and Yu (2002) investigated the impact on student academic performance and attitude of incorporating e-mail. The results provided empirical evidence to support the use of e-mail as an aid to promote student cognitive growth.

A fundamental hurdle faced by students in following Web-based programmes of study, is acquiring the technical skills to perform the necessary online activities. Canning (2002) looked into the possible problems involved in Web-based learning. For those who were able and willing to embrace it, the results were encouraging: they felt 'lucky and privileged' to have access to this technology. But many students are 'hostile' to such advanced technology. Technical support must, therefore, be provided together with an initial in-person training session with detailed and clear instructions. Furthermore, students should be provided with a list of required competencies which will let

students know precisely what computer skills they need to master for various online programme requirements.

It was against this background and taking cognizance of the issues involved, that the Department of Building and Real Estate developed its online MSc/PgD programme in Project Management. Considerable effort was put into helping students overcome the hurdles that they face in distance education.

A sense of community was created among students by keeping them oriented and by providing a variety of interactions and the programme of study was designed to not only facilitate the assimilation of knowledge by students, but also to raise awareness of how the knowledge can be applied in a professional environment (Starr, 1998). Also, mindful of the suggestions of Hodson *et al* (2001) in relation to producing a successful online learning environment, the instructional design team focused on planning, student understanding and real time interaction. The proponents of this programme contend that the result is a programme that successfully links technologies and systems to educational philosophies and practices and, in so doing, provides students with a rich online learning experience.

The present work is the result of a study to exchange experiences and best practices in developing online learning in order to further enhance the quality of teaching content online. It involved collaboration between two academic institutions offering similar undergraduate programmes, but in different countries, namely Hong Kong SAR and Australia. This paper reports the findings of a recent survey of the Hong Kong students only, which aims to investigate the feasibility of using ICT to deliver the subject of construction technology to undergraduate students. It provides a holistic view of student responses including feedback and perceptions on using e-learning as a means to learn construction technology. It will describe the methods, efficiency and effectiveness, as well as design considerations, for the application of e-learning in this subject.

RESEARCH METHODOLOGY

QUESTIONNAIRE SURVEY

The survey was conducted between January and March 2004. Data were mainly collected through a

questionnaire survey which aimed to investigate the perceptions of using e-learning to deliver construction technology to undergraduate students. To achieve this, an e-learning class was developed so as to deliver one of the construction technology topics called construction formwork through the platform of WebCT. Beside the commonly used written materials, including Word documents and PowerPoint presentations in classroom teaching, a set of interactive computer animations illustrating the installation and operation of dynamic formwork was provided in the e-learning class. This animation was in Macromedia Flash format. It contained expanded notes with definitions, explanations, examples and problems, etc. Students were allowed to control the speed of animation so that they could learn the whole process easily step by step. A set of short video clips demonstrating the site operation was provided as well. Most of these learning materials could be downloaded and, thus, students could reproduce them into hard copy if necessary. The e-learning class was opened to students for 24 hours in a specific period so that they could access it at their own convenience. Students were invited to complete a questionnaire after finishing the class; details of the questionnaire will be discussed below.

QUESTIONNAIRE DESIGN

The questionnaire design was based on literature review and the researchers' teaching experience of e-learning and traditional classroom (see Appendix A). It was printed on two pages of A4 paper. The questionnaire consisted of 11 multiple-choice questions and three open-ended questions. These questions covered the four major topics:

- feedback on the topic of formwork construction
- design of the e-learning materials for the subject of construction technology

- perception of applying e-learning to construction technology
- respondent's information.

For the multiple-choice questions, a set of statements were given and respondents were asked to rate these statements by choosing one of the four given options – strongly disagree, disagree, agree or strongly agree. To analyse the data, the Likert-type scale structure scoring system was adopted. Four different scores, 1 = strongly disagree, 2 = disagree, 3 = agree and 4 = strongly agree, were assigned to the options to produce their mean values for further analysis. The open-ended questions were designed to collect supplementary information about students' comments on overall, positive and negative features of particular aspects of the e-learning experience for construction technology subject.

SURVEY RESPONDENTS

The survey respondents included both part-time and full-time students enrolled in the course entitled 'BRE391 Construction Technology II' in the Department of Building and Real Estate of The Hong Kong Polytechnic University. A total of 221 copies of the questionnaire were distributed to the respondents. 185 valid replies were received (138 and 47 from full-time and part-time students, respectively), which represents an 84% response rate. The respondents' backgrounds included construction engineering and management, construction economics and management, building technology and management, and building surveying. Their profiles are illustrated in Tables 1, 2 and 4.

RESULTS

STUDENTS' ABILITY TO ACCESS AND OPERATE THE E-LEARNING PLATFORM

As shown in Table 1, the figures of the overall percentages indicate that the majority of the

TABLE 1 Experience in using computer and Internet

| | EXPERIENCE IN USING COMPUTER | | | EXPERIENCE IN USING INTERNET | | |
|-------------------|------------------------------|-------|---------|------------------------------|-------|---------|
| | FT | PT | OVERALL | FT | PT | OVERALL |
| Less than 1 year | 2.2% | 6.4% | 3.2% | 1.4% | 6.4% | 2.7% |
| 1 to 3 years | 19.4% | 21.3% | 19.9% | 22.3% | 25.5% | 23.1% |
| 4 to 6 years | 33.1% | 25.5% | 31.2% | 58.3% | 42.6% | 54.3% |
| more than 6 years | 45.3% | 46.8% | 45.7% | 18.0% | 25.5% | 19.9% |

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TABLE 2 Provision of Internet connection at home

| | FT | PT | OVERALL |
|-----------------------------|-------|-------|---------|
| No | 3.6% | 4.3% | 3.8% |
| Yes, with 56K modem service | 6.5% | 10.6% | 7.5% |
| Yes, with broadband service | 89.9% | 83.0% | 88.2% |

TABLE 3 Performance of the WebCT platform

| | FT | PT | OVERALL |
|---|--------|--------|---------|
| Student did not experience much difficulty when using WebCT | 2.7626 | 2.6809 | 2.7419 |
| The stability of WebCT was satisfactory | 2.5540 | 2.5957 | 2.5645 |
| The browsing speed of WebCT was satisfactory | 2.4388 | 2.5532 | 2.4677 |
| WebCT is an effective means to deliver the subject | 2.4173 | 2.9362 | 2.5484 |

respondents (both full-time and part-time students) had at least four years' experience of using a computer (76.9%) and the Internet (74.2%). Since their mean values are very similar, it appears that they have the same level of experience in using computers.

Table 2 shows that nearly all of the respondents (95.7%) have an Internet connection at home. And, as the monthly fee for broadband service is relatively low in Hong Kong, most of them (88.2%) have this service installed which provides a bandwidth of up to 15 megabits per second.

WebCT, which is one of the most popular e-learning platforms in the world, was used as the medium for delivering the construction technology subject through the Internet. Table 3 shows that respondents were generally satisfied with the performance of WebCT, with mean performance values ranging from 2.5484 to 2.7419 on a range of 1 to 4. Judging from the figures, it would appear that students did not experience much difficulty when using WebCT and so we can conclude that it is an effective means by which to deliver the subject.

From the results shown in Tables 1, 2 and 3, it can be concluded that most of the respondents are able to

access and operate the e-learning platform easily. They would not be expected to have any technical difficulties in navigating or retrieving online materials from the delivery platform.

EXPERIENCE IN E-LEARNING

As shown in Table 4, around 50% of the students have had no experience of e-learning. The remainder who had participated showed that the e-learning experience of full-time and part-time students is very similar.

TABLE 4 Experience in e-learning

| | FT | PT | OVERALL |
|-----------------------------|-------|-------|---------|
| No | 50.4% | 55.3% | 51.6% |
| Yes, inside the university | 29.5% | 17.0% | 26.3% |
| Yes, outside the university | 19.4% | 27.7% | 21.5% |

SURVEY VALIDATION

The coefficient of reliability of the results from the questionnaire survey was examined using Cronbach's Alpha, which is a model of internal consistency based on the inter-item correlation. It measures how well a set of items is represented by a single unidimensional latent construct. For example, the Cronbach's Alpha value will generally be low for multi-dimensional data structure. The Cronbach's Alpha values derived from the question items for the respective constructs are presented in Table 5. Their values range from 0.8441 to 0.9111, which are much higher than a reliability coefficient value of 0.8 regarded as acceptable in most social science applications. This result indicates that these constructs are very reliable. A detailed discussion of them is provided in the following sections.

RESEARCH FINDINGS**STUDENT FEEDBACK ON USING E-LEARNING AS A MEANS TO STUDY THE TOPIC OF CONSTRUCTION FORMWORK**

As described in the Research Methodology section, an e-learning lesson on the topic of construction

TABLE 5 Analysis of measurement reliability of constructs

| SECTION | CONSTRUCT | CRONBACH α |
|---------|---|-------------------|
| A | Student feedback on using e-learning to deliver the topic of construction formwork (12 items) | 0.8441 |
| B | Student perceptions on using e-learning as a delivery method for the subject of construction technology (19 items) | 0.9111 |
| C | Design considerations for using e-learning as a delivery method for the subject of construction technology (14 items) | 0.8894 |

formwork was developed as a tool to assist with the evaluation process of learning. This section describes the results of student feedback gathered after they had studied this online lesson. Respondents were asked to indicate to what extent they agreed with the statements in the questionnaire relating to their experience in the lesson. Four options were provided – strongly disagree, disagree, agree and strongly agree – and each option represented by a score of 1, 2, 3 and 4 for the purposes of data analysis. The average means for each of the statements given by respondents from the two groups of students are presented in Table 6.

Design of the topic

Table 6 indicates that students are generally satisfied with the design of the topic, with mean values ranging from 2.5860 to 2.6989. Students agreed that the online materials were well structured and presented, and can be accessed, retrieved and downloaded easily from the platform. The result indicates this particular topic is a good example to investigate the use of e-learning for the delivery of the subject construction technology.

Formats of e-learning materials

A variety of formats were used to deliver the topic, including PDF, PowerPoint and Web page. Judging from the results shown in Table 6, these formats are a convenient and effective way to deliver the content of the topic. The figures also indicate that students prefer the use of PDF and PowerPoint formats over the Web page format. One explanation for this preference is that if students wish to reproduce hard copies of the material, the fixed-size property of the formats means that the original layout of the material is retained when printed.

Overall comments

As shown in Table 6, the mean values of the part-time students are higher than those of the full-time students, which suggests that the part-time students are relatively more satisfied with the use of e-learning as a means of delivering the topic of construction formwork. The figures also indicate that both full-time and part-time students alike gained knowledge of the topic through e-learning and that they had a very good e-learning experience. Students also agreed that e-learning is a practical method by which to study the topic and that

TABLE 6 Student feedback on using e-learning to study the topic of construction formwork

| AREAS | FEEDBACK | MEAN | | | SIG.* |
|--|---|--------|--------|---------|-------|
| | | FT | PT | OVERALL | |
| Design of the topic | 1 The online learning materials were easy to access through the Internet | 2.6835 | 2.7447 | 2.6989 | 0.604 |
| | 2 The online learning materials were well structured and presented | 2.5755 | 2.7447 | 2.6183 | 0.129 |
| | 3 I was able to find my way easily around the online learning materials | 2.5324 | 2.7234 | 2.5806 | 0.099 |
| | 4 Amount of the online learning material was sufficient to facilitate my learning | 2.5036 | 2.7660 | 2.5699 | 0.017 |
| | 5 The download time for online learning materials was reasonable | 2.5683 | 2.6383 | 2.5860 | 0.565 |
| Delivery methods of learning materials | 6 Lecture notes in PDF format were a convenient and effective way to deliver the content of this topic | 2.6043 | 2.9149 | 2.6828 | 0.005 |
| | 7 Lecture notes in PowerPoint format were a convenient and effective way to deliver the content of this topic | 2.5468 | 2.7021 | 2.5860 | 0.162 |
| | 8 Lecture notes in web page format were a convenient and effective way to deliver the content of this topic | 2.4173 | 2.6596 | 2.4785 | 0.031 |
| Overall comments | 9 I have mastery (i.e. to learn and apply) the knowledge of this topic | 2.5108 | 2.7234 | 2.5645 | 0.074 |
| | 10 The overall e-learning experience in this topic is excellent | 2.5252 | 2.8511 | 2.6075 | 0.003 |
| | 11 It is feasible to learn this topic using e-learning method | 2.5396 | 2.7447 | 2.5914 | 0.088 |
| | 12 I will recommend this e-learning topic to others | 2.5108 | 2.6170 | 2.5376 | 0.373 |

*Significant values of the Independent Samples Test compared with the mode of study

they would recommend it to others. These results suggest that students were generally satisfied with the use of e-learning for delivering the topic of construction formwork and, by extrapolation, that they would be satisfied with its use for delivering other construction technology topics.

STUDENT PERCEPTIONS OF USING E-LEARNING AS A MEANS TO STUDY THE SUBJECT OF CONSTRUCTION TECHNOLOGY

Following on from the earlier section in which the results of student feedback in relation to the online delivery of one particular topic, namely construction formwork, were discussed, this section presents the results of students' perceptions of using e-learning as a means by which to study the entire subject of construction technology.

Learning methods

The results in Table 7 indicate that face-to-face learning is preferred to e-learning for the delivery of construction technology; the percentages are 28.5% and 7%, respectively. Part-time students appear to be more supportive of e-learning as their mean value is 4.8% higher than the full-time students'. However, the majority of students (61.8%) prefer a combination of e-learning and face-to-face learning rather than any single mode for delivering the subject of construction technology.

Learning independence

Table 8 indicates that e-learning helps both full-time and part-time students to learn this subject independently, as their mean values are almost the same. However, as the part-time students' mean value is 8.7% higher than the full-time students', it would appear that there is a stronger consensus among part-time students that e-learning improves their learning experience of the subject.

TABLE 7 Preferable learning methods for the subject of construction technology

| | FT | PT | OVERALL |
|---------------------------------|-------|-------|---------|
| Face-to-face learning | 29.5% | 25.5% | 28.5% |
| e-learning | 5.8% | 10.6% | 7.0% |
| Combination of the previous two | 61.9% | 61.7% | 61.8% |
| Others | 2.2% | 0% | 1.6% |

Learning efficiency

The mean values of 2.5645 for full-time students to 2.7527 for part-time students in Table 8 indicate that e-learning improves the learning efficiency of construction technology. Students generally feel that it is important to be able to access learning materials when and where they want and that e-learning helps them to do this. Compared with full-time students, part-time students have a stronger consensus that it was convenient to be able to download learning materials from the website. The results suggest that e-learning saves students a significant amount of travelling time that would be necessary in order to attend classes; the time saved can be used to study the subject. Overall, it may conclude that e-learning facilitates the access and retrieval of learning materials and therefore, to some extent, increases the efficiency of learning the subject of construction technology.

Learning effectiveness

The mean values of 2.61154 and 2.7234 for full-time and part-time students, respectively, reflect general agreement among the respondents that e-learning increases the effectiveness of study for the subject of construction technology. However, there is disagreement over the usefulness of e-learning in helping to achieve a better examination result in the subject. The mean values of part-time students are generally higher in this section, which suggests that e-learning is more useful to them. Overall, these results reveal that the use of e-learning for the subject of construction technology would benefit students' learning but would not necessarily improve their examination results.

Overall comments

From Table 8, it can be seen that the mean values of part-time students are generally higher than those of full-time students, which suggests that part-time students are more willing to use e-learning as a means to learn the subject of construction technology. For example, nearly 10% more part-time students agree that they would like to have construction technology subjects delivered by the e-learning methods and would be interested to enrol for these subjects if given a choice.

TABLE 8 Student perceptions of using e-learning as a means to study the subject of construction technology

| AREAS | PERCEPTIONS | MEAN | | | SIG.* |
|------------------------|---|----------------|--------|---------------|---------------|
| | | FT | PT | OVERALL | |
| Learning independence | 1 The interactive design of this e-learning subject stimulates my interests in learning | 2.5971 | 2.6809 | 2.6183 | 0.423 |
| | 2 I feel personally involved in learning this subject through e-learning | 2.5971 | 2.7234 | 2.6290 | 0.224 |
| | 3 The e-learning method helps me to learn this subject independently | 2.7914 | 2.7872 | 2.7903 | 0.969 |
| | 4 The e-learning method improves my learning experience | 2.6619 | 2.8936 | 2.7204 | 0.016 |
| | Average | – | – | 2.6895 | – |
| Learning efficiency | 5 The e-learning method increases the efficiency of my study in this subject | 2.6115 | 2.6596 | 2.6237 | 0.649 |
| | 6 Being able to access the learning materials when and where I wanted is important to me | 2.7338 | 2.8085 | 2.7527 | 0.490 |
| | 7 It was convenient to be able to download materials from WebCT | 2.4892 | 2.7872 | 2.5645 | 0.006 |
| | 8 The e-learning method allows me to learn this subject anytime and anywhere | 2.7338 | 2.7660 | 2.7419 | 0.766 |
| | 9 I can save a significant amount of travelling time in attending the classes | 2.5755 | 2.7447 | 2.6183 | 0.123 |
| | 10 I can easily manage my progress and this improves the flexibility of learning in this subject | 2.6187 | 2.6809 | 2.6344 | 0.583 |
| | 11 These (9) and/ or (10) release me from the time pressure in learning this subject | 2.5683 | 2.6383 | 2.5860 | 0.522 |
| | Average | – | – | 2.6459 | – |
| Learning effectiveness | 12 The e-learning method increases the effectiveness of my study in this subject | 2.6115 | 2.7234 | 2.6398 | 0.251 |
| | 13 The computer animation incorporated into the online learning materials for describing the construction process was more effective than face-to-face teaching | 2.5324 | 2.7021 | 2.5753 | 0.178 |
| | 14 The e-learning method generally assists me to achieve a better examination result in this subject | 2.4676 | 2.6596 | 2.5161 | 0.126 |
| | | Average | – | – | 2.5771 |
| Overall comments | 15 I support that the e-learning method is an effective approach to learn the subject of construction technology | 2.5468 | 2.6809 | 2.5806 | 0.193 |
| | 16 I would like to have more construction technology subjects topics delivered by the e-learning methods | 2.5755 | 2.8298 | 2.6398 | 0.032 |
| | 17 Given a choice, I would enrol in a construction technology subjects delivered by e-learning method | 2.4604 | 2.6170 | 2.5000 | 0.167 |
| | 18 I will recommend the e-learning method to others for learning the subject of construction technology | 2.5468 | 2.7447 | 2.5968 | 0.042 |

*Significant value of the Independent Samples Test compared to the mode of study

In summary, the results in Table 8 indicate that students believe e-learning to be useful in helping them to study the subject of construction technology by improving learning independence, learning efficiency and learning effectiveness, but they do not feel that e-learning will help to improve their exam results. This is discussed further in the next section.

DESIGN CONSIDERATIONS FOR USING E-LEARNING AS A DELIVERY METHOD FOR THE SUBJECT OF CONSTRUCTION TECHNOLOGY

Design criteria

Some factors are considered more important than others when using e-learning as a means to study the subject of construction technology. Table 9 shows how

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TABLE 9 Design criteria for the subject of construction technology

| RANK* | FACTORS | MEAN* | | | SD | | | SIG.** |
|-------|-------------------------|--------|--------|---------|---------|---------|---------|--------|
| | | FT | PT | OVERALL | FT | PT | OVERALL | |
| 1 | Ease of access | 2.8705 | 3.0213 | 2.9086 | 0.75981 | 0.76583 | 0.76210 | 0.246 |
| 2 | User friendly interface | 2.8633 | 3.0000 | 2.8978 | 0.80038 | 0.65938 | 0.76779 | 0.249 |
| 3 | Speed of access | 2.8561 | 2.8085 | 2.8441 | 0.81259 | 0.85053 | 0.82028 | 0.738 |
| 4 | Interactive hyperlinks | 2.7194 | 2.7021 | 2.7151 | 0.78969 | 0.85757 | 0.80504 | 0.903 |
| 5 | Multimedia presentation | 2.5971 | 2.8298 | 2.6559 | 0.80505 | 0.86776 | 0.82521 | 0.110 |
| 6 | Navigation | 2.5468 | 2.7234 | 2.5914 | 0.77294 | 0.77184 | 0.77441 | 0.179 |
| 7 | Interactive activities | 2.4532 | 2.7447 | 2.5269 | 0.80957 | 0.79312 | 0.81329 | 0.033 |
| 8 | Feedback mechanism | 2.4317 | 2.5957 | 2.4731 | 0.86853 | 0.82514 | 0.85855 | 0.248 |

*Ranking in descending order

**Significant value of the Independent Samples Test compared with the mode of study

TABLE 10 Preferable types of e-learning materials

| RANK* | FACTORS | MEAN* | | | SD | | | SIG.** |
|-------|--------------------------|--------|--------|---------|---------|---------|---------|--------|
| | | FT | PT | OVERALL | FT | PT | OVERALL | |
| 1 | Photographs and pictures | 3.1583 | 3.4255 | 3.2258 | 0.84493 | 0.61661 | 0.80039 | 0.022 |
| 2 | Drawings | 3.0576 | 3.4043 | 3.1452 | 0.86619 | 0.64806 | 0.82881 | 0.005 |
| 3 | Text/written materials | 2.9856 | 3.1702 | 3.0323 | 0.75167 | 0.60142 | 0.71963 | 0.092 |
| 4 | Computer animations | 2.8777 | 3.2128 | 2.9624 | 0.84665 | 0.72039 | 0.82769 | 0.010 |
| 5 | Videos | 2.8273 | 3.1702 | 2.9140 | 0.87583 | 0.73186 | 0.85305 | 0.010 |

*Ranking in descending order

**Significant value of the Independent Samples Test compared with the mode of study

the students rank these factors in descending order of importance. The mean values of the factors range from 2.9086 to 2.4731, with the part-time students generally displaying a higher mean value for each of the factors than the full-time students; this could indicate that the part-time students more strongly support the factors. The results also suggest that, although their studying environments are different, the design criteria for full-time and part-time students can be similar.

Types of e-learning materials

Table 10 presents the respondents' preferred type of e-learning materials for the subject of construction technology. The material types are displayed in descending order of preference as indicated by their respective mean overall value. As can be seen from Table 10, the students' preferred e-learning material type is 'photographs and pictures', followed by 'drawings' and 'text/written materials'.

It is worthy of note that the mean values and standard deviations of part-time students are generally higher and lower, respectively, than those of full-time students. For example, the mean values of 'video' and 'computer animations' for part-time students are 12.1% higher than for full-time students, and the standard deviation values for 'photographs and pictures' and 'drawings' are approximately 26% lower than for full-time students. These figures suggest that there is a greater consensus among part-time students for the use of different types of e-learning materials, and perhaps a stronger demand from them for a greater variety of such materials.

DISCUSSION OF THE FINDINGS

The findings of the research on the use of e-learning to deliver the subject of construction technology to undergraduate students are presented in the above sections. In summary, e-learning is considered to be a practical method to improve students' learning of the

subject. These findings will be discussed in detail in this section.

FEASIBILITY OF USING E-LEARNING TO DELIVER CONSTRUCTION TECHNOLOGY

Based on research findings described in previous sections, e-learning is a practical method to deliver the subject of construction technology. Most undergraduate students, especially full-time students, were highly experienced in the use of computers and the Internet: around 50% of the students have more than six years' experience of using them. Students did not have much difficulty in accessing and operating the e-learning platform, despite the fact that no initial training session was provided in the research. This contradicts the common belief that computer skill is a major obstacle to the implementation of e-learning. It is also observed that the students were generally satisfied with the e-learning lesson and they have satisfactorily learned the topic of construction formwork through e-learning. Most students, especially the part-time students, tended to agree that the overall e-learning experience is excellent and they would recommend this approach to others.

In addition, the results suggest that e-learning could help students to improve learning independence, learning efficiency and learning effectiveness to a certain extent in learning the subject of construction technology. There is a strong consensus among students that e-learning can improve their learning experience. It is interesting to know that students feel that they have been personally involved in learning the subject through e-learning, based on the results from Table 8. This indicates that the sense of isolation, which is common among students undertaking distance learning (Barker *et al*, 1989; Eastmond, 1995), may not be a key problem in the mixed mode of delivery (face-to-face and e-learning). As shown in previous sections, the students believe that the use of e-learning for the subject of construction technology would benefit their learning but would not necessarily improve their examination results.

The research also revealed that e-learning is more useful to the part-time students than the full-time students. The mean values of the part-time students are generally higher than those of the full-time students,

which reveals that they have a higher level of satisfaction and confidence in the application of e-learning. Part-time students appear to be more supportive of e-learning than the full-time students. These findings are in line with the result that more part-time students would like to have additional construction technology topics delivered by the e-learning method in future. There are two possible reasons for these differences:

- As the full-time students come to campus on a regular basis in the daytime, they would have fewer difficulties caused by time or proximity constraints in attending conventional taught classes compared with the part-time students. As a result, the flexible nature of e-learning, which releases them from time pressure, becomes less useful in learning the subject.
- E-learning generally requires a tremendous amount of self-discipline to make progress in the self-learning process. The part-time students, who usually have several years' working experience, are believed to be more mature and have a higher level of self-discipline and independence in meeting this challenge.

PREFERRED MODE OF LEARNING

These results suggest that the use of any single mode of learning is inadequate and it is highly recommended to combine e-learning and face-to-face learning in delivering the subject of construction technology. The findings show that the single mode of face-to-face learning is preferred to the mode of e-learning. Students are accustomed to face-to-face interaction and two-way communication in conventional learning, and are reluctant to learn with a new learning method.

The study also shows that most students prefer the combination of e-learning and face-to-face learning rather than any single mode. They are in favour of adopting the e-learning method as a supplement to the traditional method of teaching and learning. This finding was similar to the study by Zou *et al* (2003) and indicates that the benefits of e-learning and face-to-face learning methods are largely different and, thus, their drawbacks can be cancelled out through combining them. Besides, it is observed that there is a

tendency for the students simply using e-learning as a tool to obtain information that may otherwise be given as handouts in a traditional face-to-face lecture or tutorial. It is noted that the preferred e-learning materials in studying the subject of construction technology are 'static materials' such as photographs and pictures, as opposed to dynamic materials such as animation and videos. The reason for this may be that static materials can be converted to hard copy easily for studying purposes, which is in line with students' preference for PDF and PowerPoint formats, both of which are easily convertible to hard copy. Given the strong orientation of Hong Kong students towards examinations, this is not surprising. This suggests that students may not exploit the full potential of e-learning and may simply apply e-learning to substitute or support the manual process of the traditional learning method.

CONCLUSIONS

The feasibility, effectiveness, efficiency and potential benefits of using e-learning to deliver the subject of construction technology for undergraduate students have been examined and discussed in this paper. In conclusion, the research findings suggest that e-learning is considered to be a practical method to study the undergraduate subject of construction technology. It is useful to help the students improve their learning independence, learning efficiency and learning effectiveness to a certain extent. E-learning is more useful to part-time students than full-time due to differences in learning characteristics and requirements. Nevertheless, these improvements would not result in achieving a better examination result in the subject. In addition, research findings reveal that the single mode of face-to-face learning is preferred to the mode of e-learning for delivering the subject of construction technology. However, most students prefer the combination of e-learning and face-to-face learning rather than any single mode. They favour adopting the e-learning method as a supplement to the traditional method of teaching and learning. The study showed that students may not fully explore the advantages of e-learning and there is a tendency for them to use it merely as an information distribution tool in the learning process.

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APPENDIX A

Survey on the Application of E-learning for Construction Technology

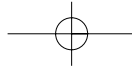
INSTRUCTION

This survey is conducted to investigate the application of e-learning in delivering the subject of Construction Technology II. Please complete this questionnaire WITH REFERENCE TO TOPIC LECTURE 13 – FORMWORK CONSTRUCTION on WEBCT by putting a ✓ to indicate your answers in the appropriate boxes. All the collected information will be used for academic purposes only and will be kept strictly confidential.

SECTION A: FEEDBACK ON THE TOPIC OF FORMWORK CONSTRUCTION

1. To what extent do you agree that the following statements relate to your experience in learning the **topic** of formwork construction?

| | STRONGLY | | STRONGLY | |
|---|--------------------------|--------------------------|--------------------------|--------------------------|
| | AGREE | AGREE | DISAGREE | DISAGREE |
| a) I did not experience much difficulty when using WebCT. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| b) The stability of WebCT was satisfactory. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| c) The browsing speed of WebCT was satisfactory. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| d) WebCT is an effective means to deliver this topic. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| e) The online learning materials on WebCT were easy to access through the Internet. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| f) The online learning materials on WebCT were well structured and presented. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| g) The amount of material placed on WebCT was sufficient to facilitate my learning. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| h) I was able to find my way easily around the online learning materials. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |



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| | STRONGLY AGREE | | STRONGLY DISAGREE | |
|--|--------------------------|--------------------------|--------------------------|--------------------------|
| i) The computer animation incorporated into the online learning materials for describing the construction process was more effective than face-to-face teaching. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| j) Lecture notes in PDF format were a convenient and effective way to deliver the content of this topic. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| k) Lecture notes in PowerPoint format were a convenient and effective way to deliver the content of this topic. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| l) Lecture notes in web page format were a convenient and effective way to deliver the content of this topic. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| m) It was convenient to be able to download necessary materials from WebCT. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| n) The download time for online learning materials was reasonable. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

SECTION B: DESIGN OF THE E-LEARNING MATERIALS FOR THE **SUBJECT** OF CONSTRUCTION TECHNOLOGY

2. To what extent do you agree that the aspects listed below are very important in using e-learning as a delivery method for the **subject** of Construction Technology?

| | STRONGLY AGREE | | STRONGLY DISAGREE | |
|----------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| a) User friendly interface | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| b) Speed of access | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| c) Ease of access | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| d) Interactive activities | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| e) Feedback mechanism | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| f) Multimedia presentation | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| g) Interactive hyperlinks | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| h) Navigation | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

3. To what extent do you agree that the following items are very important for you to understand the subject matters?

| | STRONGLY AGREE | | STRONGLY DISAGREE | |
|-----------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| a) Photographs and pictures | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| b) Drawings | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| c) Videos | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| d) Text/written materials | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| e) Computer animations | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

4. To what extent do you agree that the presentation of the materials on the website in relation to improving knowledge and understanding of the **topic** being studied is very important?

- Strongly Agree Agree Disagree Strongly Disagree

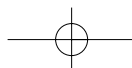
SECTION C: PERCEPTION OF APPLYING E-LEARNING TO CONSTRUCTION TECHNOLOGY

5. What is your preferred learning method for the topic of formwork construction?

- Face-to-face E-learning Combination of the previous two Others (Please Specify)

6. To what extent do you agree with the following statements relating to your experience in learning the topic of formwork construction?

| | STRONGLY AGREE | | STRONGLY DISAGREE | |
|--|--------------------------|--------------------------|--------------------------|--------------------------|
| a) The online e-learning materials are valuable and they improve my learning experience. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| b) The interactive design of this topic stimulates my interests in learning. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |



| | STRONGLY | | STRONGLY | |
|--|--------------------------|--------------------------|--------------------------|--------------------------|
| | AGREE | AGREE | DISAGREE | DISAGREE |
| c) I feel personally involved in learning this topic. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| d) I have mastery (i.e. to learn and apply) the knowledge of this topic. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| e) I can save a significant amount of travelling time in attending the classes. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| f) I can easily manage my progress and this improves the flexibility of learning in this topic. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| g) These (e) and/ or (f) release me from the time pressure in learning this topic. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| h) I'm satisfied with this topic based on the e-learning method. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| i) The overall e-learning experience in this topic is excellent. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| j) It is feasible to learn this topic using e-learning method. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| k) The e-learning method increases the effectiveness (e.g. learning performance) of my study in this topic. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| l) The e-learning method increases the efficiency (e.g. productivity) of my study in this topic. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| m) The e-learning method helps me to learn this topic independently. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| n) The e-learning method allows me to learn this topic anytime and anywhere. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| o) Being able to access the learning materials when and where I wanted is important to me. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| p) The e-learning method generally assists me to achieve a better examination result in this subject. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| q) I will recommend this e-learning topic to others. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| r) I support that the e-learning method is an effective approach to learn the subject of construction technology. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| s) I would like to have more construction related subjects topics delivered by the e-learning methods. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| t) Given a choice, I would enrol in a construction technology course delivered by e-learning method in the future. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| u) I will recommend the e-learning method to others for learning the subject of construction technology. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 7. What is the BEST thing in the topic of formwork construction? | | | | |
| 8. What is the WORST thing in the topic of formwork construction? | | | | |
| 9. How can the topic of formwork construction be further improved? | | | | |

SECTION D: RESPONDENT'S INFORMATION

| | | | |
|---|--|--|--|
| 10. Studying Course: | | | |
| <input type="checkbox"/> BEM2 | <input type="checkbox"/> BS2 | <input type="checkbox"/> CEM2 | <input type="checkbox"/> HDBTM – Sur. |
| <input type="checkbox"/> BEM1 (PT) | <input type="checkbox"/> BS1 (PT) | <input type="checkbox"/> CEM1 (PT) | <input type="checkbox"/> HDBTM – Eng. |
| 11. Number of years in using computers: | | | |
| <input type="checkbox"/> Less than 1 year | <input type="checkbox"/> 1 to 3 years | <input type="checkbox"/> 4 to 6 years | <input type="checkbox"/> More than 6 years |
| 12. Number of years in using Internet: | | | |
| <input type="checkbox"/> Less than 1 year | <input type="checkbox"/> 1 to 3 years | <input type="checkbox"/> 4 to 6 years | <input type="checkbox"/> More than 6 years |
| 13. Do you have Internet access at home? | | | |
| <input type="checkbox"/> No | <input type="checkbox"/> Yes, with 56K modem service | <input type="checkbox"/> Yes, with broadband service | |
| 14. Have you ever enrolled in any e-learning subject(s) before? | | | |
| <input type="checkbox"/> No | <input type="checkbox"/> Yes, in PolyU | <input type="checkbox"/> Yes, outside PolyU | |