SUPPLEMENTING THE VIRTUAL LEARNING ENVIRONMENT FOR INFORMATION SYSTEMS GRADUATE EDUCATION

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MASTER OF SCIENCE BY RESEARCH IN BUSINESS MANAGEMENT

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ABSTRACT

The rapid development of information technology (IT) has inspired the development of Information Systems (IS) graduate education. Virtual learning environments (VLEs) have also emerged in recent years. The VLE is valuable for IS education. However, current VLEs are not specially designed for IS graduate education and some required functions are missing.

The situation of IS graduate education is investigated by reviewing the webpages for IS programmes and courses in top business schools in the selected areas. The investigation confirms the important role of IS education and e-business education in business schools and in MBA programmes. Case studies, laboratory experiments and team projects are the most frequently used teaching methods in IS graduate education. This investigation provides valuable information for identifying the requirements of the VLE for IS graduate education.

Based on the investigation result, a range of functions are identified as the required functions of the VLE for IS graduate education. Among these, the virtual laboratory function is missing in current VLEs. A virtual laboratory prototype, which can facilitate the use of software installed on the remote server, is developed. This prototype satisfies the requirements of the experiment on Caliach Vision in Aston Business School. How to revise the prototype to meet the requirements of the VLE for IS graduate education is suggested. Finally, the virtual laboratory is integrated into the current VLE to complete the VLE for IS graduate education.

KEY WORDS:

information systems education, e-business education, MBA education, reviewing webpages, prototyping

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CHAPTER 1 INTRODUCTION

1.1 Research background

In recent years, the information technologies (IT) have had a significant impact on business. The effective and efficient use of IT has become a crucial factor for organisations to provide quality products and services, and to achieve competitive advantage (Gorgone, *et al.*, 2000). Macro-economic and cross-industry studies have also clearly proved that IT has had a positive impact on the US economy (Ives, *et al.*, 2002). Different information systems have been utilised in organisations to facilitate business processes. The information systems (IS) industry has expanded to create, manage, programme, and operate information systems both inside and outside organisations (Gorgone, *et al.*, 2000).

The rapid development of IS has resulted in a high demand for information system professionals (Gupta & Wachter, 1998). Despite the Y2K issues and the burst of the dot.com bubble, the demand for information systems professionals is still at the steadily growing level predicted before the dot.com anomaly occurred (Ives, *et al.*, 2002). Many IS graduate programmes and courses have been developed in higher education institutions in response to the high demand from professionals. In 2000, more than 90 universities in the US were providing IS graduate programmes (Gorgone, *et al.*, 2000).

Another effect of the continuing breakthroughs in IT is the fast development in the educational technology area. Various models and frameworks of virtual learning environments (VLEs) have been proposed or developed in recent years (e.g. Cloete, 2001; Ismail, 2002; Nachmias, 2002; Parikh & Verma, 2002; Sheremetov & Arenas, 2002; Weller, 2002). The software providers are also active in developing and promoting their VLE solutions, such as Aspen, Blackboard, Learning Space, TopClass, and WebCT.

VLE means the learning management software system that delivers course material through networks and facilitates communication and interaction among the teachers and the students (Britain & Liber, 1999; Piccoli, *et al.*, 2001). Some higher education institutions have employed VLEs in order to facilitate teaching and learning since it overcomes the time and space limitation of the traditional classroom education environment. The empirical research on using the VLE in higher education achieves consistent results that VLEs provide better support for collaborative learning, discussion-led learning, and student-centred learning compared with the traditional classroom-based, face-to-face learning environment (Britain & Liber, 1999; Hsu & Backhouse, 2001; Papp, 1999). These researchers also argue that VLEs are able to provide leads, references and useful information related to the learning content and help the students to learn flexibly. These features of the VLE properly meet the requirement of an effective business education system (Lengick-Hall & Sanders, 1997).

The VLE is also valuable for IS graduate education. The empirical research in using VLEs in IS education confirms the benefits (Lu, *et al.*, 2003). The VLE should be a good tool to help IS education to meet its challenges. However, current VLEs are not specially designed for IS education and cannot provide some functions required by IS education. VLEs do not provide a sound solution for conducting experiments through the Internet, while laboratory experiments are considered as an important part of IS education (Gorgone, *et al.*, 2000; Gorgone, *et al.*, 2002; Ives, *et al.*, 2002). Current VLEs require supplements to meet the requirements of IS graduate education.

1.2 Aims and objectives

This research project aims to supplement the VLE for IS graduate education. Some IS programmes and courses are using VLEs to support teaching and learning. However, it is concluded from the literature that some functions required by IS graduate education are still missing in the VLEs. Most of the current VLEs are designed to suit for the general education requirements, but IS graduate education may have some different requirements. These required functions should be designed and integrated into the current VLEs. This is the main objective of this research project. To identify these specific requirements, the situation of IS graduate education must been known first. Therefore, an investigation into the situation of IS graduate education will be made in this research project. The prerequisite to identifying the requirements of the VLE includes reusing traditional learning resources and teaching methods, and employing the advantages of IT. After the requirements are clarified, the missing functions of the VLE for IS graduate education will be developed. One clear missing function of the VLE is the virtual laboratory which can help students to conduct IS experiments in the VLE, so this function will be designed in the research first. The other missing functions of the VLE, if any, will also be developed after the investigation. Therefore, the research project includes the following two main parts:

- Investigation into the situation of IS graduate education to identify the requirements of the VLE for IS graduate education; and
- Design of the virtual laboratory to supplement the VLE for IS graduate education.

1.3 Layout of thesis

In Chapter 2, the literature on IS graduate education is reviewed. This review aims to clarify the background information on IS graduate education. It includes the scope of IS education, the objective, content and teaching methods of IS graduate education, the features of IS graduate education, and the newest developments in IS graduate education.

Chapter 3 is the literature review on VLEs. The concept and features of VLEs are clarified, and then the advantages and disadvantages of VLEs are discussed. When the background information on both IS graduate education and the VLE are clear, an initial discussion on the requirements of the VLE for IS graduate education is carried out.

Chapter 4 discusses the methodology of the research project. The research includes an investigation into IS graduate education and a virtual laboratory prototype design. The research methods for these two parts are justified. The research processes of the research are discussed.

The investigation into IS graduate education is described in Chapter 5. The objective of the investigation is to provide adequate information to identify the requirements of the VLE for IS graduate education. The investigation focuses on the content, the teaching methods, and the features of IS graduate education. The situation of e-business education, the role of IS courses in MBA programmes, and the difference between different locations of IS graduate education are also discussed. Finally, the requirements of the VLE for IS graduate education are identified.

Chapter 6 explains the design of the virtual laboratory. A virtual laboratory prototype is developed in parallel with the investigation on IS graduate education. When the requirements of the VLE for IS graduate education are identified, this prototype is revised in line with them. Lastly, it is integrated into the VLE for IS graduate education.

Finally, the key findings of this research project are summarised in the last chapter, Chapter 7. The limitations of the research are also discussed in this final chapter.

1.4 The meaning of some terms

Before the discussion on IS education begins, some terms need to be defined to avoid confusion, because they have different meanings in the UK and in the US. In this thesis, "programme" and "course" will be used according to their usage in the US. Here "course" means a unit of a curriculum. It shares the same meaning as "module" in the UK. "Programme" means a complete body of prescribed studies constituting a curriculum, which often means a "course" in the UK.

Chapter 2 Literature Review: Information Systems Graduate Education

2.1 Information systems degree programmes

Ever since computers were first utilised to report and process transactions in organisations, the field of IS has been developing at an amazing rate. Information systems collect, process, store, and distribute information to support decision making, coordination, and control in organisations. Information systems also help to identify and analyse problems, visualise complex subjects, and create new products and services (Laudon & Laudon, 2003). Information systems support processes at all management levels including operational level, tactical level, and strategic level. Information systems have extended to different departments within all kinds of organisations. Though many information systems fail to accomplish the expected goals (Mann, 2002), Information systems are still regarded as one of the crucial factors for organisations to provide quality products and services, and to achieve competitive advantage (Gorgone, *et al.*, 2002).

During four decades of growth and change, different labels have been utilised to represent the academic field of IS, and the area it covers has been enlarged. The following terms present a list of names associated with this academic field (Gorgone, *et al.*, 2002):

- Information Systems
- Management Information Systems
- Computer Information Systems
- Information Management
- Business Information Systems
- Informatics
- Information Resources Management
- Information Technology
- Information Technology Systems

- Information Technology Resources Management
- Accounting Information Systems
- Information Science
- Information and Quantitative Science

However, the most widely accepted, generic name to describe this academic discipline is Information Systems (IS).

Many researchers have indicated their different opinions of the scope of IS. Among these researchers, Gorgone, *et al.* (2002) provides the most comprehensive definition: IS as an academic field includes the concepts, principles, and processes for two broad areas of activity within organisations:

- the acquisition, deployment, and management of IT resources and services. It has the responsibility to cover the knowledge on how to plan, develop or acquire, implement, and manage the IT infrastructure, data, and systems. It also answers for tracking new IT and incorporating it into the organisation's strategy, management, and operation. To support departmental and individual information systems is also its responsibility;
- the development, operation, and evolution of infrastructure and systems for use in organisational and inter-organisational processes. These processes require the IS professionals to utilise the technology and methodologies on design, development or acquisition, and implementation. They also require the integration of the concepts of business process design, innovation, quality, human-machine systems, human-machine interfaces, e-business design, socio-technical systems, and change management.

The rapid expansion of information systems leads to the high demand for IS professionals (Gupta & Wachter, 1998). Many researchers have suggested the characteristics of information systems professionals (Gorgone, *et al.*, 2002; Gupta & Wachter, 1998; Noll & Wilkins, 2002). Their suggestions are summarised as follows:

- IS professionals should have sound technical knowledge of computers, communications, and software to accomplish their jobs concerned with IT;
- IS professionals should understand organisations and the functions within organisations, such as accounting, finance, marketing, operations, human resources, and many other functions, since they need to communicate with colleagues in the organisation who are

likely have a business-educated background, and to operate organisational and inter-organisational systems.

- IS professionals should have the ability to grasp the concepts and processes for achieving organisation goals with IT.

Therefore, to educate a qualified IS professional, an IS degree programme should include not only academic content relating to the IS discipline, but also the content in other management disciplines. The content of IS education will be discussed in the next section in detail.

Graduate IS education is becoming more and more popular in recent years (Avison, *et al.*, 2001). The demand comes from both business and students. Businesses need more IS expertise to cope with the rapid development of IT, especially where companies are considering how to integrate their business strategy with information systems, and skilled IS professionals are essential to the job. Businesses find that "Although the higher education system produces large numbers of highly educated people in both information systems and computer science, skilled information systems people are in short supply in industry. Even scarcer are talented people with advanced knowledge for managing information systems" (Gorgone, *et al.*, 2000, p. 3). On the other hand, students with an IS related background hope to upgrade their knowledge and students with other backgrounds are looking for better career development after taking the IS graduate programme. It is anticipated that the high demand for IS graduate programmes will continue in the years to come (Dean & Nasirin, 2002).

2.2 IS model curricula

IS has a long history of developing and employing model curricula, so analysing the model curricula of IS education is the most convenient way to grasp an initial understanding of IS education. Since the early 1970s, task groups have been working towards the model curriculum in IS (Gorgone, *et al.*, 2000; Gorgone, *et al.*, 2002). Now, the academic associations that represent their members from worldwide academic and/or professional fields are steering the model curriculum development. These associations include:

- Association for Computing Machinery (ACM)
- Association of Information Technology Professionals (AITP, formerly DPMA)
- International Federation for Information Processing (IFIP)

- Association for Information Systems (AIS)

During the development of the model curricula, many academics have published their experiences or relevant research results through journals and conferences to provide references for them. Therefore every model curriculum is a comprehensive summary of the research in IS education.

The latest two important model curricula in IS education are MSIS 2000 and IS 2002. MSIS 2000 is for graduate degree programmes and IS 2002 is for undergraduate degree programmes. They are the latest research results of the series model curricula developed by ACM and AIS. They have the best generality and are regarded as the standard IS curriculum in IS education research (Lidtke, *et al.*, 1999; Holmes & Hayen, 1999). Many IS programmes, particularly the programmes in the US and Canada, utilised these two model curricula as reference models to design the curriculum for their own programme (Gorgone, *et al.*, 2002).

Both of the MSIS 2000 and IS 2002 can be utilised in business schools or in engineering schools. Their curriculum design is based on typical degree programmes in the United States and Canada, but they are also relevant to programmes in other countries. Programmes in other countries can easily adapt these model curricula to suit their requirements.

Because the undergraduate programmes provide the foundation courses for the graduate programmes, both of the model curricula are reviewed in the following sections, though the research is focus on IS graduate education.

2.2.1 IS 2002

IS 2002 is a model curriculum for undergraduate degree programmes in IS. It is a collaborative effort of ACM, AIS, and AITP in 2002 (Gorgone, *et al.*, 2002).

The IS 2002 model curriculum suggests the presentation areas of the IS curriculum which are shown in Figure 1. The dotted boxes describe the areas outside the IS discipline but which should be included in the IS curriculum while the other boxes describe the core IS courses. The other five boxes depict the presentation area which is the core area of the IS curriculum and should be taught by the IS faculty. The sequence in which the presentation area is taught is also shown in the figure.

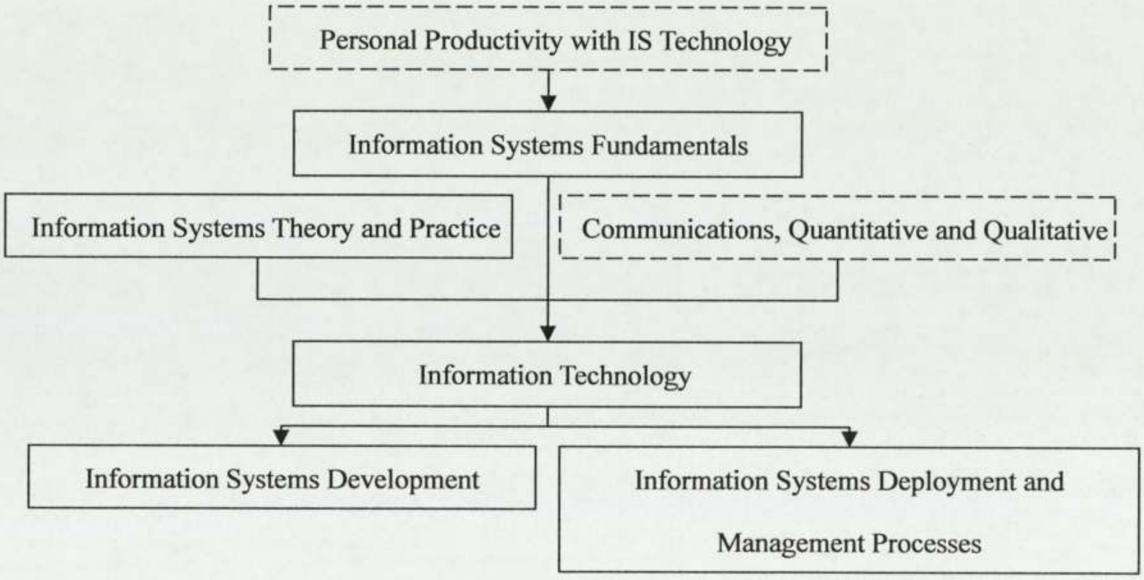

Figure 1. IS 2002 presentation areas (adapted from Gorgone, *et al.*, 2002)

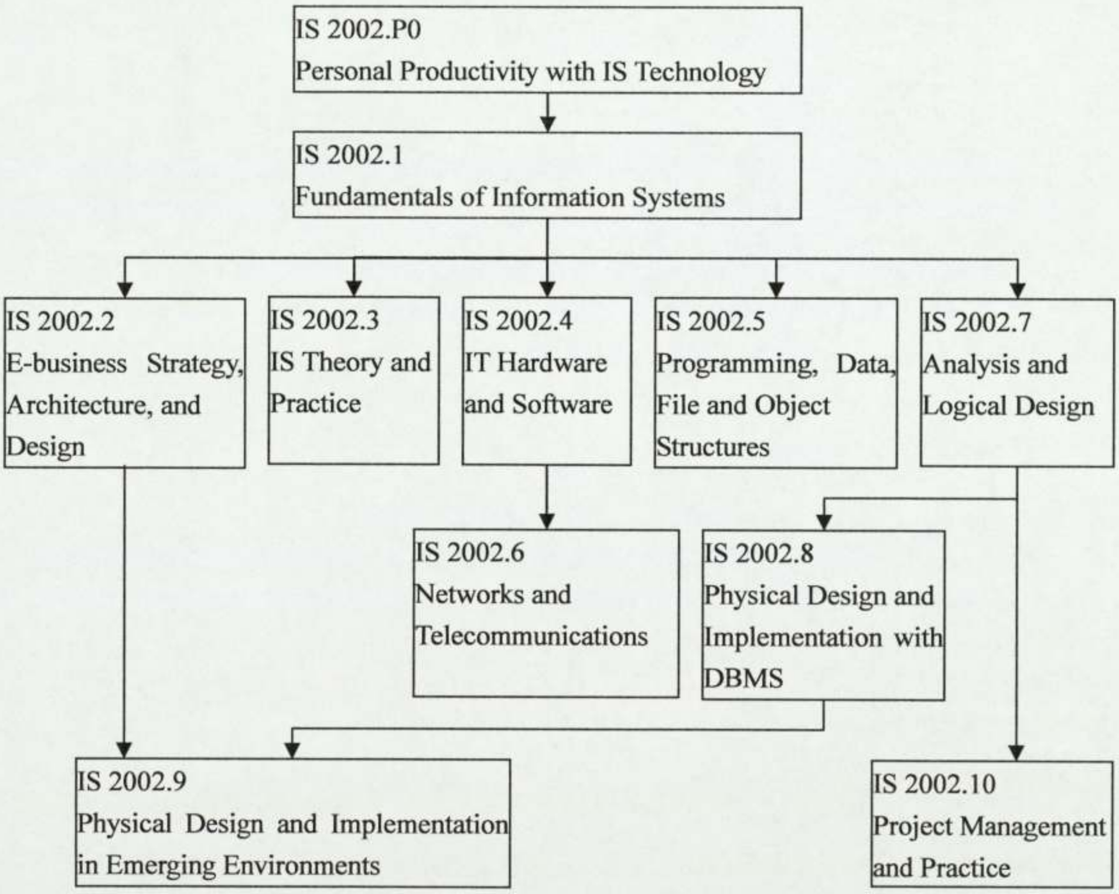

Figure 2. IS 2002 course architecture and sequence (adapted from Gorgone, *et al.*, 2002)

The course architecture and sequence of courses within IS 2002 are diagrammed in Figure 2. The courses are labelled from IS 2002.P0 to IS 2002.10. Figure 3 matches the courses to the presentation areas.

PERSONAL PRODUCTIVITY WITH IS TECHNOLOGY
IS 2002.P0 Personal Productivity with IS Technology
INFORMATION SYSTEMS FUNDAMENTALS
IS 2002.1 Fundamentals of Information Systems
IS 2002.2 Electronic Business Strategy, Architecture, and Design
INFORMATION SYSTEMS THEORY AND PRACTICE
IS 2002.3 Information Systems Theory and Practice
INFORMATION TECHNOLOGY
IS 2002.4 Information Technology Hardware and Software
IS 2002.5 Programming, Data, File and Object Structures
IS 2002.6 Networks and Telecommunications
INFORMATION SYSTEMS DEVELOPMENT
IS 2002.7 Analysis and Logical Design
IS 2002.8 Physical Design and Implementation with DBMS
IS 2002.9 Physical Design and Implementation in Emerging Environments
INFORMATION SYSTEMS DEPLOYMENT AND MANAGEMENT PROCESSES
IS 2002.10 Project Management and Practice

Figure 3. IS 2002 presentation areas and courses (adapted from Gorgone, *et al.*, 2002)

Compared with the previous model curriculum, IS '97, most courses in IS 2002 had no significant changes. However, IS 2002.2 (E-Business Strategy, Architecture, and Design), is added to the curriculum as a new course. This course has been added to the model curriculum because of the rapid development in Internet technology and the fast pace of change in Internet-based commerce.

Furthermore, the model curriculum also suggests a variety of pedagogical approaches for the courses. Though classroom lecturing is still the most important teaching method, it is also suggested that laboratory experiments and team projects be used in many courses.

2.2.2 MSIS 2000

MSIS 2000 is the latest model curriculum for the Master of Science in Information Systems (MSIS) programmes. It is a joint effort of AMC and AIS in 2000 (Gorgone, *et al.*, 2000).

This model curriculum suggests that graduates of the MSIS programme should have the following skills, knowledge, and values:

- A core of IS knowledge
- Integration of IS and business foundations
- A broad business and real world perspective
- Communication, interpersonal, and team skills
- Analytical and critical thinking skills
- Specific skills leading to a career

Figure 4 depicts the course architecture of the MSIS 200 Model Curriculum. The curriculum is composed of five building blocks: IS Foundations, Business Foundations, IS Core, Integration, and Career Electives.

The courses in the "IS Foundations" block and the "Business Foundations" block are the prerequisites for the programme. The courses in the "IS Foundations" block are selected IS core courses from the undergraduate IS programme. The "Business Foundations" block should include at least three courses. One of them should be on internal organisation considerations; another one on external organisation considerations, and the third one should focus on a certain area of business. The list of courses in the "Business Foundations" block of Figure 4 is only one example.

IS Foundations	**Business Foundations**	**IS Core**		**Career Electives**
Fundamentals of IS IT Hardware and Software Programming, Data and Object Structure	Financial Accounting Marketing (Customer Focus) Organisational Behaviour	Data Management Analysis, Modelling and Design Data Communications and Networking Project and Change Management IT Policy and Strategy	**Integration**	Tracks (representative): • Consulting • Decision Making • Electronic Commerce • Enterprise Resource Planning • Globalisation • Human Factors • Knowledge Management • Managing the IS Function • Project Management • Systems Analysis and Design • Technology Management • Telecommunications
Prerequisite		Required		Elective

Figure 4. MSIS 2000 Model Curriculum (adapted from Gorgone, *et al.*, 2000)

The “IS Core” block includes five courses. The first two courses of this block, “Data Management” and “Analysis, Modelling, and Design” are mainly in the technical aspects of IS, while the third course, “Data Communications and Networking”, focuses on technical as well as managerial aspects. The other two courses “Project and Change Management” and “IS Policy and Strategy” are mostly in managerial aspects. The core courses from both technical and managerial areas present the idea that the MSIS programme should combine IS and business culture. These courses should reflect the new developments in technology, be close to the real world and be practical.

The “Integration” block includes at least one course emphasising the integrative role of IS. Three perspectives of integration are recommended: integrating the enterprise, integrating the IS function, and integrating IS technologies. The perspective of integrating the enterprise emphasises organisational issues at the enterprise level, including some application courses such as Enterprise Resource Planning (ERP), Supply Chain Management. The perspective of integrating the IS function focuses on managing the IS function within an organisation, and the perspective of integrating the IS technology is concerned with the technologies required to achieve the integration. The integration course can cover one of the perspectives, or combine two or all three of the perspectives.

This model curriculum suggests that an MSIS programme should have some career elective courses which lead to certain career tracks. A career track is composed of at least four related electives. For example, the Electronic Commerce career track is composed by “Internet, Intranet, and Extranets”, “Electronic Commerce”, “WWW and the Value Chain”, and “Consumer Relationship Marketing”. The career track should be multidisciplinary and reflect the nature of the track.

The model curriculum also gives advice on the teaching methods for each course. Case studies is suggested in the managerial courses, while laboratory experiments and team projects are proposed in the technical courses. Other suggested pedagogical approaches include industry speakers and student presentations.

2.2.3 Features of IS graduate education

By reviewing the preview research in IS graduate education and the model curricula, the features of

IS graduate education are summarised as follows:

- A multidisciplinary nature. IS graduate programmes should include content not only relating to technical aspects but also to managerial aspects. These two reviewed model curricula are balanced on both technical and managerial orientation. An IS graduate programme can have either a technical orientation or a managerial orientation. The curriculum is greatly influenced by the orientation. The number of courses in different areas, the breadth and depth of the courses should be configured for the different orientations. The students should take note of and understand the programme orientation before they enrol in the programme. Nowadays, most of the IS programmes in the US and the UK are balanced on both technical and managerial aspects (Avison, *et al.*, 2001).
- Rapidly developing content. The content of IS is developing rapidly, both in the technology and the managerial aspects. The IS programme should update the curriculum frequently to reflect new developments. Moreover, IS graduate programmes should also train the students in learning ability, which can ensure they maintain their advantages in the rapidly developing IS field (Dawson & Newman, 2002).
- Variety of teaching methods. A variety of teaching methods, including case studies, laboratory experiments, individual or team projects, industry speakers, student presentation, and video, are used in IS programmes (Avison, *et al.*, 2001; Gorgone, *et al.*, 2000). An appropriate teaching method delivers the knowledge more effectively and more efficiently. The instructors should be familiar with the different teaching methods and have the ability to select the most suitable teaching methods for different content.

Differences are found between the graduate programmes and the undergraduate programmes. Graduate programmes certainly have a higher requirement on learning content than undergraduate programmes. Graduate programme focus more on practical issues. Graduate programme require the students to have better skills in communicating and collaborating with others, and to integrate technology knowledge and business knowledge to solve problems.

The above discussion focuses on IS graduate programmes. But IS also can be taught as a course in graduate programmes. The previous research on IS as a course also concentrated on what content should be included in the course (Ives, *et al.*, 2002; Shuayto & Borchers, 2001). Their discussions are not only on the balance of managerial aspects and technical aspects, but also on the balance of practical skills and theories. Overall, these researches suggested that IS theory and strategy should be introduced to the students, while IS practical skills should also be taught in the IS course. Another focus of the research is the role of IS courses in business schools, especially in MBA programmes (Avison, 2003; Ives, *et al.*, 2002). These researchers argued that IS courses are an important part of business education, and it should be a core course for all business students.

2.3 New developments in IS graduate education

By reviewing the IS model curricula and some literature on IS education, new developments in IS graduate education are discovered. One finding is the development of electronic business (e-business) education; another is the practical skills training in IS graduate education.

2.3.1 Development of e-business education

The word "e-business" has been assigned many different meanings and scopes. In this research project, the broadest meaning of e-business has been used. Here e-business not only includes the narrower meaning of e-business, which is "servicing customers, collaborating with business partners, and conducting electronic transactions within an organisation" by using computers and networks (Turban, *et al.*, 2002, P4), but also includes electronic commerce, which "describes the process of buying, selling or exchanging products, services, and information via computer networks" (Turban, *et al.*, 2002, p5). Because sometimes e-business and e-commerce can be used interchangeably, in the following discussion, e-commerce and related courses and programmes would be considered as equal to e-business courses and programmes. The word e-business education will be used to represent the courses and programmes in this field.

In recent years, the e-business market has expanded rapidly. Even after the shakeout of dot.coms starting in the third quarter of 2000, forecasts for e-business were still optimistic (Chan, 2001). The persistent significant growth in B2B and B2C Internet commerce sales has proved the importance of e-business to the economy.

The expansion of the e-business market has driven the emergence of many e-business courses and programmes in recent years, especially at the graduate level (Dean & Nasirin, 2002; Nickerson, 2000). By the spring of 2001, 25% of US MBA programmes offered an e-business or e-business related major (Keenan, 2001). According to a survey for the top fifty business schools in the UK in 2002, 44% of the schools offered at least one e-business course in an MBA programme, and 58% of the schools offered e-business courses in the non-MBA masters programmes (Dean & Nasirin, 2002). In Asia, most top MBA programmes planned to develop e-business courses or have already provided e-business courses (Bacani, 2000). In the IS 2002 model curriculum, e-business has been added as a core course. In the MSIS 2000 model curriculum, a career track of e-business is suggested. E-business instructors publish their ideas and experiences in conferences and journals. Workshops and panels are established in the conferences to discuss the development of e-business education (Dean & Nasirin, 2002).

Different opinions exist on the content of e-business programmes and courses. By summarising the research on this problem (Brookshire, *et al.*, 2000; Chan, 2001; Dean & Nasirin, 2002; Nickerson, 2000), the main content area of an e-business programme includes:

- Communications/network infrastructure
- Web technology (development, security, management)
- Data processing/data analysis/database management
- Internet market/strategic marketing/market research
- Strategy management/e-business strategy
- Supply chain management (SCM)
- Customer relationship management (CRM)
- Enterprise resource planning (ERP)

In other words, these content areas compose the scope of e-business education, though a clearer boundary is still needed. It is clear that this scope is within the scope of IS education, therefore e-business education should be considered as a part of IS education.

The research on e-business indicates the consistency in the teaching methods of e-business courses. Case studies and team projects are suggested as important pedagogical approaches. Some improvements to the traditional approaches are also suggested in the teaching methods:

- Case studies. Because of the rapid changes in the field of e-business, the long process of developing a case study may reduce the timely usefulness of the case, and the case also becomes outdated quickly (Bacani, 2000; Dean & Nasirin, 2002). Some instructors require the students to review the companies' websites instead of reading the written cases. This is a more effective method to keep the information updated for both teachers and students.
- Team projects. Some innovations are suggested for team project. For example, one collaborative approach has been used in DePaul University. The students from two e-business classes play different roles in a project. The students from one class serve as the consultants for the e-business application developers who are played by students from another class (Chan & Wolfe, 2000).

Though these innovative teaching methods have provided excellent examples for tackling the challenges in e-business education, some difficulties have been discovered in the development of e-business programmes and courses:

- The fast pace of change of the e-business environment. The rapid development in the field makes the learning materials become quickly outdated. The curriculum of the e-business programmes needs to be changed frequently. Instructors have to spend a lot of time on learning new developments in order to keep updating the curriculum. The best solution for this problem is to invite industry professionals to give lectures on the cutting edge courses, since they have more experience in facing the complexity of both technology and best practices (Chan & Knight, 2000; Dean & Nasirin, 2002).
- The high cost of infrastructure investment. The e-business programme needs to provide a high-speed connection to the Internet for the students. Computer laboratories and classrooms with comprehensive equipment, such as high-performance servers, workstations, and digital projectors are also necessary. The programme also needs to select a suitable platform and prepare a full set of software ranging from operation systems, database server to webpage design and programme development tools. And technical support is also an essential factor for a successful e-business programme (Bacani, 2000; Chan, 2001; Chan & Knight, 2000; Rob, 2002). Some e-business systems, such as SCM system, CRM system, and ERP system, which are relatively expensive in the commercial software market, are also needed in the relevant courses. Collaboration with industry and application service providers is the most effective solution to

reduce the investment in infrastructure. Inter-college collaboration is another option (Chan, 2001).

Overall, e-business education is still in its initial stage. The boundary of the courses needs to be clarified. Though some innovative pedagogical approaches have been suggested for e-business education, some problems on its development are still waiting to be solved. More research is needed in this area.

2.3.2 Practical skills training in IS graduate education

The skill of solving practical problems has been considered as an important ability of IS graduates (Gorgone, *et al.*, 2000). But some research has indicated that the IS programmes still fail to provide enough training on practical skills for the graduates, although the students are required to work with effect as soon as they begin their career (Veal & Maj, 2001). Fortunately, many IS programmes have put more effort into training in practical skills in recent years. In both model curricula discussed above, the practical skills training is suggested to be an important part of the IS programme, while the model curricula for graduate programmes put even more effort into this area.

Practical skills training in IS graduate education includes training in the skills on using the technologies and the skills on applying the management theories. It can be a course of the programme, or a series of workshops, or just a technology experience. Up till now, most practical skills training has been on the technical aspect, such as Hawking & McCarthy (2000) and Veal & Maj (2001).

Many IS programmes find that to collaborate with industry is a good way of providing practical skills training. Some companies providing IS products and services, such as IBM, Cisco, Oracle, and SAP have launched their university collaboration projects. They provide their products and services at no or very low cost for the collaborative programmes for training the students. Many schools welcome these alliances and take part in them. The schools believe that the collaboration can provide better chances for the students to learn the highly demanded practical skills by accessing high-quality, industry-standard products. The students' feedback on the collaborative programmes is also very positive. (Hawking & McCarthy, 2000; Nelson, 2002; Watson, E. E. & Schneider, 1999)

Some problems exist in practical skills training. The following shows the difficulties identified in the previous research (Flatto, 2000; Nelson, 2002):

- The high cost of infrastructure investment. A computer laboratory is a necessity to deliver the practical skills training in technology. Moreover, some software packages need a complex infrastructure to implement. For example, a complicated ERP system would require an application server, a database server, many high performance workstations and a dedicated system administrator. Even though collaboration with industry could reduce some investment, the investment in infrastructure is still a burden for many programmes.
- Instructors must spend a long time preparing the training. They have to understand in depth the whole hardware and software environment for practical skills training before they can design experiments. Furthermore, designing the experiments and writing the experiment guide is also very time-consuming.
- Difficult to assess the learning effect. While some experiments can have a standard result, many others cannot. The assessment for the latter kind of experiment is complicated.

In summary, practical skills training is considered as an important part of IS education. IS programmes can collaborate with IT companies to provide the training. However, providing the training is challenging and still limited by several problems.

2.4 Summary of IS graduate education

The background and development of IS graduate education is reviewed in this chapter. IS graduate education has been developing rapidly in recent years. IS graduate education should have a good balance between the technical aspect and the managerial aspect. Though some areas in IS have been well developed and are relatively stable, the continually emerging new information technologies and IS concepts put IS graduate education in a rapidly changing environment. A variety of teaching methods have been used in IS graduate education. E-business education, as a part of IS education, has emerged quickly and has been developed into a programme in many universities, though some difficulties limit its development. Practical skills training is another new development in IS graduate education. However, many problems and difficulties are also discovered in IS graduate education, and much effort is still needed to be put into this field.

Chapter 3 Literature Review: Virtual Learning Environments

3.1 Concept of the VLE

Virtual learning environments (VLEs) are defined as the learning management software systems that deliver course materials through networks and facilitate communication among the participants (Britain & Liber, 1999; Piccoli, *et al.*, 2001).

VLEs are similar to computer aided instruction (CAI) with respect to the functionality of delivering course materials, yet the VLE concepts are broader than that of CAI. VLEs utilise the network to support communication and interaction among the participants. This means the learning process in a VLE is collaborative and interactive, while CAI is a self-contained individual environment and does not facilitate the learners' interaction with other participants, (Piccoli, *et al.*, 2001).

The differences between the VLE and the traditional classroom education environment can be clarified by comparing the following six dimensions (Piccoli, *et al.*, 2001):

- Time. Students determine the time and pace of instruction independently when instruction is delivered asynchronously. Students can review the instruction as many times as they want.
- Place. Learners access the learning material and communicate with other participants and instructors through computers and networks. Learners can be in any location with network connections.
- Depth. A variety of learning resources can be accessed through VLEs. They can be linked to each other. The information provided by VLEs can be much richer than that provided in the classroom.
- Technology. Participants usually use a Web browser to access the learning resource and communicate and interact with other participants. A variety of information technologies will be used in VLEs to facilitate the teaching and learning process. In the traditional

classroom learning environment, the technology used is relatively simple.

- Interaction. VLEs allow many-to-many interaction among all the participants including student-to-student and student-to-instructor throughout the learning process. Different kinds of communication technology can be applied to facilitate the interaction. In the traditional classroom environment, the interaction is mainly controlled by the instructor. It would be difficult to interact among all the participants.
- Control. VLEs provide much higher learner control than traditional classroom education and greater personalisation of instruction.

Stimson (1997) suggested that a VLE should have the following function modules: virtual meeting place, virtual laboratory, library system, course notes, assessment, and information system. Here it is clear that every function module represents one function area of the traditional classroom environment. According to his suggestion, a VLE should at least be able to provide the same quantity and quality of service as the traditional classroom environment. Most VLEs are designed not only to reproduce the classroom environment through the network and computer interface, but also to utilise the technology to facilitate learning and teaching (Britain & Liber, 1999). VLEs intend to accommodate different learning goals and provide a tailor-made learning environment for every individual participant. They aim to encourage interaction and collaboration among all the participants in the learning process. They also help to share and reuse the learning resources. Overall, VLEs employ the different new information technologies in order to provide better support for education than the traditional environment.

The users of a VLE could include: on-campus students, off-campus students, students in industry, instructors, and managers (Stimson, 1997). Among these users, students are the major users of the VLE. Students in different categories have different characteristics:

- On-campus students. This group of students has access to the university's physical facilities. They use VLEs to access the courses which are only available on-line or the courses taught in a classroom yet with some resources available in a VLE. They usually use the university's local network to connect to the VLE.
- Off-campus students. This group of students is probably working during the day. They have limited physical contact with their classmates and instructors. They usually use the VLE to

access on-line courses. They may use a telephone modem, ISDN, ADSL or cable modem to connect to the VLE. Because the cost for broadband connection is decreasing, they may have higher bandwidths in the future.

- Students in industry. This group of students might use the VLE provided by their companies or by the universities. They take the course relevant to their work, and may require just-in-time training. They use the company network to connect to the VLE, so their bandwidths are likely higher than that of students at home.

VLEs should support all three kinds of students equally, though different users have different requirements concerning learning resources and technologies. Moreover, VLEs should also be easily used by the instructor. The instructors will not expect that using the VLE will increase their work burden.

3.2 Features of the VLE

Currently different kinds of VLEs are available. While some software companies provide their VLE solutions, some universities design and develop their own VLEs and academic researchers are active in proposing and developing different kinds of VLEs (Cloete, 2001; Ismail, 2002; Nachmias, 2002; Parikh & Verma, 2002; Sheremetov & Arenas, 2002). Though every VLE has its unique features, some common features also exist. Five leading commercial VLEs, including LearningSpace, Aspen, TopClass, WebCT and Blackboard, were investigated in the research project in order to summarise the basic features of a VLE. Their shared features are summarised in the following:

- Web-based. There are clear signs that the World Wide Web has become the most important technology for delivering information. The Web can deliver different types of course materials to learners across the globe. The learners only need to use the browser to connect to the VLE and do not need to install any application in the terminal. Web-based is the most common standard of the VLEs.
- Content design and content management. The VLEs provide different tools for content design and content management. The VLEs all support content input in text, picture, audio, video, and other multimedia formats. Some VLEs, such as WebCT, can even import the content directly from the file created by offline applications such as Macromedia

Dreamweaver, Microsoft FrontPage, and Microsoft PowerPoint.

- Virtual Classroom. All the five VLEs provide well-designed virtual classrooms. The virtual classroom can support multipoint video and/or audio transaction, shareable whiteboard, PowerPoint presentation, Web touring, application sharing, and some other tools. By utilising these tools, the VLEs can reproduce the traditional classroom environment at the maximal level and provide an even more convenient instruction environment.
- Communication and collaboration. The VLEs utilise e-mail, discussion board, chat room, whiteboard, and instant message tools to assist communication among learners and instructors. Many functions in the VLEs, such as shareable whiteboard, PowerPoint presentation, Web touring, and application sharing, are designed to facilitate collaboration among the participants.
- Assessment and auditing. Assessment can be added to the learning processes in the VLEs. The assessment tools include multiple choice, true/false, and fill-in the blank. The VLEs can grade the assessment automatically and provide feedback to the learners immediately. The auditing function of the VLE enables the instructor to monitor the activities of the learner and provide help for the user behaviour analysis.

Every VLE has its unique features. Some features may imply the future development direction of VLEs. They are summarised as follows:

- Standardisation. Some VLEs comply with leading industry standards. Standardisation is considered as an essential feature for future VLEs. Standardisation is needed by the VLEs for two main reasons: (1) learning resources can be defined, structured, and presented using a standard format; (2) learning resources in a standard format can be shared with and reused by another VLE in a straightforward way (Anido-Rifon, *et al.*, 2001). Different organisations have defined the standards in different areas of VLEs. The most important standards for VLEs are the standards on learning metadata and learner profiles.
- The ability to integrate with other applications. Though some research has indicated the disappointing situation of the VLEs' ability to integrate with other applications (Lytras & Pouloudi, 2001), all five investigated VLEs have some functionality in integrating with other applications. However, the function areas of integration are different. For example, LearningSpace can easily be integrated with the knowledge management systems from

Lotus; Blackboard and WebCT can be integrated with student information systems, authentication schemes and library systems.

- Simulation. Simulation has been proven to be an effective way for both teaching and learning. It is considered as a important tool that should be included in VLEs (Davies, 2003). However, among the five VLEs, only Aspen provides the simulation function. Aspen provides a Simulation Editor module in the VLE package. This module can be used to create high-fidelity learning content which simulates target application closely (Click2Learn.com, 2003).

3.3 Effectiveness, strengths and weaknesses of VLEs

3.3.1 Effectiveness of VLEs

Much research has been conducted into assessing the effectiveness of VLEs in different courses (Hsu & Backhouse, 2001; Morrissey, 1998; Papp, 1999; Piccoli, *et al.*, 2001). In some aspects, VLEs provide even better support than the traditional learning environment for teaching and learning. Papp (1999) argued that the VLE enables the instructors to devote more time to preparing and planning the course and to help the students on an individual basis, while they spend less time on the logistics. Hsu & Backhouse's research (2001) indicated that the VLE helps the learners to develop friendships with others and to increase their critical thinking skill. Morrissey (1998) found that the performance in the case study is better when the discussion is supported by the VLE.

On the other hand, some research indicated the drawbacks of the VLE. Students may experience feelings of isolation in VLEs (Brown, 1996). They may also feel frustration, anxiety, and confusion (Hara & Kling, 2000). Moreover, they may reduce their interest in the subject matter (Maki, *et al.*, 2000).

However, a more common opinion is that there is generally no significant difference in learning effectiveness between the VLE and the traditional classroom environment. Some researchers believe that the learning outcome is not determined by the technology, but by the instructional implementation of the technology (Piccoli, *et al.*, 2001).

3.3.2 Strengths and weaknesses of VLEs

Many universities have utilised VLEs in their daily education activity. The major benefits of VLEs are identified as follows:

- Flexibility in learning time and place. The VLE enables the student to access the learning resources anytime and anywhere with the network connection. Students can save the time and cost of travelling to and from the campus (Huynh, *et al.*, 2003). It also makes it possible for the participants to have just-in-time learning. This feature would be especially valuable for the off-campus students and the students in industry.
- Student-centred learning. The students can tailor-make the learning environment according to their preference. They can also control the process and pace of the learning (Britain & Liber, 1999).
- Sharing and reusing resources. The learning resources in VLEs can be shared and re-used in another learning module or unit, or even in other VLEs. This feature helps to save the cost and time of developing the learning resource (Britain & Liber, 1999).
- Collaborative working. The communication and interaction tools of VLEs benefit collaboration among the participants. A variety of technologies is applied to support the communication and increase the effectiveness and efficiency of collaboration (Morrissey, 1998).
- Reducing the administration burden. Supported by the learning administration function of VLEs, the instructors can be free from the administration job. VLEs can help to assess the learning process with more detail in an easier and more accurate way (Britain & Liber, 1999).
- Coping with increased student numbers. When the number of students is beyond a certain amount, the average cost of educating a student in the VLE will be less than that in the traditional classroom learning environment. This difference increases rapidly with the expansion of student numbers (Huynh, *et al.*, 2003). It is more economical to utilise VLEs when student numbers are rising.

However, weaknesses of VLEs have also been identified:

- Investment on infrastructure and systems. A reliable infrastructure is essential for the success of VLEs. To employ the VLE, the computer network may need to be upgraded and new servers may be required. To obtain the VLE, whether by purchasing a commercial VLE or by developing in-sourcing or out-sourcing, needs a large amount of money and time. Moreover, dedicated system administrators are required to maintain the VLE (Huynh, *et al.*, 2003).
- Cost of obtaining learning resources. The learning resources in VLE can be classified into two main categories. One kind of learning resource is the traditional computer-based learning resource. This kind of learning resource includes PowerPoint files, Word files, PDF files, HTML files and some other files which are usually developed in the instructor's computer or downloaded from the Internet and then uploaded to the VLE. This kind of learning resource does not utilise the communication and interaction functions of VLE. They are independent of each other. The students just download them from the VLE to their personal computers and then open and view the learning resources. VLEs only act as file exchange server for this kind of learning resource. This kind of learning resource does not really use the advantages of the VLE though they are simple and inexpensive to be developed. The other kind of learning resource is specially designed for the VLE. They link to each other, and integrate the functions of the VLE into the learning processes. The students stay in the VLE to access the learning resources so that they can utilise the advantages of the VLE. There are two ways to obtain this kind of learning resource for the VLE. One is to purchase from the content vendors. For example, there are more than 1500 course packages in more than 50 subject areas for WebCT (WebCT.com, 2003). The other way is for the instructors to create the learning resources using the content design tools in the VLE. Academic institutions gain their learning resources mainly through the latter. A report in 2000 by a faculty committee at the University of Illinois concluded that using the VLE to teach is more costly and time-consuming for a university than using traditional classroom teaching (Huynh, *et al.*, 2003). It would be true, especially when the student numbers are not large enough or the instructors have not been accustomed to using the content design tools and content management tools. Many instructors still find it difficult and time-consuming to create the learning resources for the VLE, even though VLE developers have put much effort into simplifying this process.

- Limited support for on-line experimentation. Experimentation is considered as an important part of education in many subject areas. But no VLE in the investigated VLEs has provided a sound solution to support these learning activities. The simulation function in Aspen can be used to support some experiments which aim to demonstrate a known process. However, the simple simulation tool is still far from enough to satisfy the requirements of experimentation.

3.4 VLEs for IS graduate education

VLEs have already been utilised in some IS graduate programmes. Some aim to provide additional learning resources for the courses which are mainly taught in the traditional classroom environment. Some programmes used VLEs to provide on-line courses where students do not have classroom instruction. The research in this area shows a positive result of using VLEs in IS graduate education (Hsu & Backhouse, 2001; Lu, *et al.*, 2003; Papp, 1999).

The VLE is a suitable solution to facilitate IS graduate education. They are most suitable for collaborative, student-centred learning (Leidner & Jarvenpaa, 1995), which is appropriate for IS education. The literature review on IS graduate education shows that the IS programmes encourage the students to be collaborative and to be active in the learning process. VLEs provide an ideal learning environment for the IS graduate students. The collaboration and communication tools in the VLE can also provide adequate support for students' interaction and cooperation.

The VLE can help the instructor to maintain the learning resources more effectively and efficiently. In the VLE, the instructor can utilise the learning resources from the Internet much more easily. The learning materials can link to the different information providers to provide the newest information. The Internet acts as a huge information source for learning resources in the VLE. This characteristic of VLEs can provide strong support for IS instructors to cope with the rapid development in the field.

Moreover, utilising VLEs in learning can enrich the students' computer experience. The VLE is one kind of information system for education. VLEs themselves are an excellent example for study in IS.

The experience in using VLEs can also enhance students' experiences in using computers and networks and enhance their computer literacy.

However, one function which is necessary for supporting IS graduate education is missing in the VLEs. This function is the support for laboratory experiments, which is usually called a virtual laboratory. A virtual laboratory is defined as "a computer system that models a place, situation or the like conducive to experimentation, investigation or observation" (Stimson, 1997, p15). Researchers have successfully designed and implemented virtual laboratories in some academic areas, such as physics and chemistry (Cartwright & Valentine, 2002; Stimson, 1997). However, no VLE has been found to be able to provide a sound solution for virtual laboratories in IS education. More research should be conducted on this problem to supplement this missing function of the VLE for IS education.

The VLEs may also need some other improvements to suit IS graduate education. Simply reviewing the literature in IS education is not enough to master the comprehensive situation of IS graduate education. Perhaps more requirements of the VLE for IS graduate education would be identified after a more comprehensive investigation on the current situation of IS graduate education.

In summary, the VLE has proved to be able to provide effective support for IS education, though some improvement is needed. More detailed requirements need to be identified after a comprehensive investigation into the situation of IS education. A virtual laboratory which can support experiments in IS graduate education should be developed for the VLE for IS graduate education.

Chapter 4 Research Methodology

4.1 Overview of research methodology

As introduced in Chapter 1, the research project consists of the following two parts:

- Investigation into the situation of IS graduate education to identify the requirements of the VLE for IS graduate education, and
- Design of the virtual laboratory and other missing functions to supplement the VLE for IS graduate education.

In the traditional system design approach, the identification of requirements should be finished before the system designing starts. However, as discussed in Chapter 3, the virtual laboratory is a clear required function of the VLE for IS graduate education. The virtual laboratory development can be more practical if the real users can participate in the evaluation of the virtual laboratory. But if the virtual laboratory development begins after the investigation into the situation of IS graduate education, the time would not be enough to allow the users to evaluate the virtual laboratory because of the time limitation of the research project. In order to increase the efficiency of the research project, a virtual laboratory prototype is developed while the situation of IS graduate education is being investigated. These two parts of the research are conducted in parallel. When the situation of IS graduate education is identified, the requirements of the VLE for IS graduate education will be clarified. Then if any new requirements have been found, the required new functions will be developed. Finally, the virtual laboratory prototype and the other new functions will be integrated into the VLE. This research process can ensure the virtual laboratory is more practical and suitable for general situation. The whole process of the research project is depicted in Figure 5.

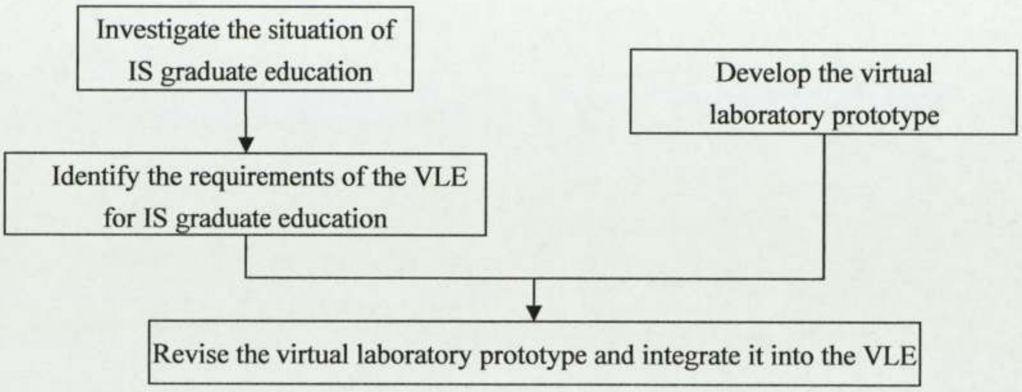

Figure 5. Process of the research project

4.2 Research method of the investigation and the VLE requirements identification

4.2.1 Justification of the research method of the investigation

The first part of the research project is to investigate the situation of IS graduate education. The investigation result will be use to identify the specific requirements of the VLE for IS graduate education. Though many requirements of the VLE have been suggested in previous researches, the specific requirements of IS graduate education can be identified only based on the comprehensive understanding of the situation of IS graduate education.

The requirement identification needs balanced information both in depth and breadth. If the depth is not enough, the detailed requirements cannot be identified. If the breadth of the information is not enough, the result may only reflect part of the requirements and the final result of the research would not be able to provide a sound solution for worldwide IS graduate education. There is already some research that provides information in the depth aspect, such as the model curricula and some case studies on IS graduate education (Holmes & Hayen, 1999; McCubbrey, 1999; Watson, E. E. & Schneider, 1999; Watson, E. F. & Schneider, 1998). However, little research in the field can provide comprehensive information about the current IS graduate education situation worldwide. Therefore, this research project will focus on the breadth research of IS graduate education. The research should confirm whether the IS courses and programmes over a broad range have similar features to that found in the previous depth research. The research also aims to search for more undiscovered features in IS graduate education.

A questionnaire survey is the most popular research technique to collect information over a broad range. By using questionnaires, the researcher is able to collect the information from a broad range of responders in an effective way (Saunders, *et al.*, 2000). The research can be made even more effective by using Web-based questionnaires (Dochartaigh, 2002). However, several problems exist for using questionnaires in this research project:

- Building a proper respondent list. Whether the proper respondents can be found is one key factor which significantly affects the quality of the responses. The ideal respondents for the investigation are the instructors, administrators, and students of the IS programmes or courses. But there is no such list of the worldwide IS programmes and courses, and to build this list would be far too difficult and time-consuming for the research project.
- Designing the questions. The questionnaire should not include too many open questions, because these questions need more time to answer and thus lead to a lower response rate. Furthermore, open questions also increase the difficulty of coding the response. In this research, several questions, such as the objective of the course, the content of the course and the teaching methods used in the course, have to use open questions to get detailed and accurate responses.
- Response rate. Response rate can be seen as an indicator for the efficiency of the research. A survey with a low response rate can lead to an inaccurate and useless research result. The response rate will become even lower if the researcher is unable to find the right respondents and asks too many open questions in the questionnaires. Some previous research on similar topics using questionnaires did not come to a satisfactory research result because of the low response rate (Britain & Liber, 1999; Lomerson & Schwager, 2003).

In summary, according to the above benefit and problem analysis, questionnaire survey does not suit the research on the situation of IS graduate education.

However, an alternative way, which is reviewing the webpages of the IS graduate programmes and courses, might be more effective and efficient for this part of the research. The World Wide Web has become an important information source. Using the Internet as a data-gathering tool has been widely accepted (Hewson, *et al.*, 2003). Many universities and programmes have developed their websites to provide information for potential students and for those who are interested in the universities and programmes. It is possible to collect abundant information on IS programmes and courses in different countries through the Internet. The main benefits for reviewing the webpages are summarised as follows:

- Flexibility. The researcher can totally control the time and place to perform the investigation, and the level of detail of the research can be controlled as well. The researcher can visit the webpage again any time to search for more information or for updated information conveniently. The researcher is freer to explore the features of the IS programmes and courses by reviewing the webpages for the IS programmes and courses than by using questionnaires, interview, or other research methods.
- Updated information. Usually the webpage will provide the most up-to-date information. Therefore, the research can summarise the latest situation of IS education.
- Save time. With the help of search engines and portal websites, locating the webpage for the IS programmes and courses would not be difficult. When the webpage has been found, the information about the programme or course can be collected and at the same time the data coding process can also be conducted. Using this research method, much time can be saved. For example, the time of building the potential respondent list for the questionnaires or of making appointments for the interviews can be saved.

On the other hand, there are also some weaknesses in utilising this research method:

- Incomplete information. Not all webpages for the IS programmes or courses provide comprehensive information for the investigation. Some webpages might only offer a brief description for the course or programme, but do not provide all the required data.
- Unstructured information. The information on the webpages might be unstructured. The webpages for different programmes or courses might provide the same kind of information in different places, so the author might have to read through all the webpages to locate the right information.
- Lack of interaction. Using the other research techniques, the interaction between the researcher and the information provider might help to generate some new ideas or suggestions for the research. However, this kind of interaction would not exist in reviewing the webpages. Also,

when the author is not sure about the meaning of the information, the webpage is not able to provide explanations.

Overall, although reviewing the webpages of IS programmes and courses has some limitations, it is still the most suitable research method for the investigation. As stated above, the investigation mainly focuses on the broad research of IS graduate education, so the research should cover a relatively large range of IS programmes and courses. Therefore, research methods such as interview, case study and observation are not suitable for this investigation. In this case, questionnaire survey and reviewing the webpages are the candidate research methods. However, in the case of using questionnaires, the samples of the research project might not be adequate and the required time might be too long. Therefore, questionnaire survey may not be able to provide enough information to clarify the situation of IS graduate education. Reviewing the webpages of IS programmes and courses can ensure that the research covers an adequate number of samples, though some of the sample might not provide comprehensive enough information. The samples without comprehensive information can be excluded in the data analysis to avoid affecting the analysis result. Therefore, this research method is more suitable for the research. As a result, reviewing the webpages of IS education is selected as the research method for the investigation of IS graduate education.

4.2.2 Sample selection

Since the objective of the research is to investigate the worldwide situation of IS graduate education, the ideal way is to collect information about every IS graduate programme and course in the world and then generalise the findings. But it is impracticable and not necessary to investigate all the programmes and courses. Generalising the ideas from representative samples can be broadly accepted and obviously reduce the time and cost for the research (Saunders, *et al.*, 2000).

Because there is no list of worldwide IS graduate courses and programmes, and building such a list is far too time-consuming for the research project, the complete range of IS graduate education cannot be clarified. Therefore, sample selection methods from statistics cannot be directly used in this research. The following are some criteria for selecting the samples defined by the author:

- Geographic area. The samples in the research are mainly selected from three geographic areas:

the United Kingdom, the United States, and the Asia Pacific area. The universities in these three geographic areas can represent different education systems and the different levels of education development. There are also several broadly accepted university rankings for these areas which can provide comprehensive information for selecting the right universities as samples. Moreover, English is the main language for these areas so the researcher can understand the information provided by the universities correctly and easily. There are also some famous universities located outside the three geographic areas. These universities will also be included in the investigation, although they will not be categorised into any location groups.

- From top business schools. The main objective of this part of the research is to explore the requirements of the VLE for IS graduate education. The new requirements are more likely to be found from high-quality courses or programmes because they have more resources to utilise the new technologies and to explore new pedagogical approaches. But there are few broadly accepted rankings for IS graduate programmes and courses. However, there are many rankings for business schools and for their MBA programmes. Most IS programmes are hosted by the business schools of universities, and MBA programmes usually include some IS courses. In general, the IS programmes in the top business schools and the IS courses in the top MBA programmes should be better than the IS programmes and courses from other universities. Therefore, the samples can be selected from the IS courses and programmes hosted by the business schools which have been ranked top in any of the broadly accepted business school and MBA rankings. IS programmes and courses are also found in engineering schools in some university. It is concluded from the literature review, however, that few engineering schools have utilised the VLE in their IS programmes and courses, and a source of rankings for engineering schools is not available, therefore the IS programmes and courses in engineering schools are not included in the samples.
- Sample size. Because the research will not make any statistical inferences, a larger sample size will not produce a higher level of significance. However, the sample size still affects the breadth of the research and the possibility of determining new requirements. A larger sample size would produce a more valuable research result. But the sample size will also be limited by the feasibility of the duration of the research project as an MSc project.

4.2.3 Data collection and analysis method

To achieve the objective of the investigation, the key data of the research are the content and teaching methods of IS education. The data of IS education includes the data from IS programmes and from IS courses. At the programme level, the major data include the objectives of the programme and the course structure of the programme. The information at the programme level cannot directly imply the teaching contents and teaching methods, but it provides important background information for the teaching contents and teaching methods in IS graduate education. At the course level, major data includes the objectives of the course, the content of the course and the teaching methods of the course. The course content and teaching methods will be classified into different categories which have been identified from the previous research in IS education. A simple database will be developed to record the collected data and help to analyse them. Moreover, pilot research will be done to test whether it is practical to collect the data from the objective source and to explore whether there is some other data which should be noticed and collected.

After the data is collected, they will be analysed to see if they can confirm the research results of the previous research in IS education. And they will also be analysed to answer the following questions:

- What is the general situation of IS education? What content is included in the IS programmes and courses? What teaching methods are utilised in the IS programmes and courses?
- What is the situation of e-business education? What content is included in the e-business programmes and courses? What teaching methods are used in the e-business programmes and courses?
- What is the role of the IS courses in MBA programmes? What is the role of e-business courses in MBA programmes?
- Are there obvious differences in IS education among the three geographic area groups? What are the differences?

Among these questions, the first two items are more important for the research because their answers are directly related to the requirements of the VLE for IS graduate education. The remaining two questions are added to the research project because they can answer some questions from the previous research in IS education and provide relevant information to analyse the features of IS education, while answering these questions will not significantly increase the workload of the research project.

In summary, the research investigating the situation of IS graduate education will be conducted by reviewing the webpages for the IS programmes and courses. The samples will be selected from the top business schools which are mainly located in the UK, the US and the Asia Pacific region. The collected data will be analysed to answer several questions to provide relevant information for the identification of the VLE requirements and to explore the features of IS education.

4.2.4 Research method of the requirement identification for the VLE

The requirement identification of the VLE for IS graduate education is based on the information from the literature review on IS education, the literature review on the VLE, and the investigation into the situation of IS graduate education. This information would be comprehensive enough to identify the requirements of the VLE for IS graduate education.

This requirement identification mainly aims to identify what functions are required by the VLE for IS graduate education. The requirement identification begins by defining the framework for identifying the requirements. This analysis framework can be summarised from the previous research on VLE development. And then, the information is analysed to identify the requirements. A function model of the VLE for IS graduate education will be suggested based on the identified requirements. Finally, the functions of current VLEs are compared with the required functions of the VLE for IS graduate education to identify the missing functions for the VLE. This requirement identification and function model aims to suggest a common model of the VLE, but not for a specific university. Because every university has its own feature on IS programme and course setting, they may still need to supplement the VLE to suit for their situation.

4.3 Research method for the virtual laboratory

4.3.1 Justification of the research method

There are many different routes to develop a system. The development methods should be selected according to the different characteristics of the development project. As discussed at the beginning of this chapter, in this research the whole virtual laboratory development process can be divided into two main stages. The first stage is conducted in parallel with the investigation of the situation of IS graduate education. The objective of the first stage is to develop a virtual laboratory prototype. The second stage is conducted when the requirements of the VLE of IS graduate education are identified. The objective of the second stage is to revise the virtual laboratory prototype to cater for the general situation of IS graduate education and to integrate the virtual laboratory into the VLE for IS graduate education.

The first stage of the virtual laboratory development aims to develop a virtual laboratory prototype. Because the host school of the author, Aston Business School, provides a chance to implement and evaluate the prototype in a graduate course, this stage can utilise the rapid application development (RAD) route. RAD emphasises user involvement in the rapid and evolutionary construction of working prototypes of a system to accelerate the system development process (Whitten, *et al.*, 2001). The process of developing the prototype is named as prototyping. Prototyping is employed as the system development method in RAD. The details of the RAD and prototyping will be explained in the next section. The main benefits of using RAD in this research can be analysed as follows:

- RAD emphasises speed (Whitten, *et al.*, 2001). Saving time in the first stage of virtual laboratory prototype development makes a longer time available for the investigation for the requirements and the development tasks in the second stage.
- RAD is widely recommended as an excellent mechanism for requirement elicitation and validation (Hickey & Dean, 1998; Janson & Smith, 1985). Though it is clear that a virtual laboratory should be added into the VLE for IS education, the detailed requirements of this function are not very clear. With the user's involvement, identifying and verifying the detailed requirements is easier, and the research results are more practical.
- RAD is proved to be suitable to test and develop a conceptual understanding of problem solutions (Janson & Smith, 1985). Using RAD in the first stage of virtual laboratory development can deepen the author's understanding of the whole VLE for IS graduate education, therefore the requirement identification of the VLE for IS graduate education will be more accurate.

The second stage of development begins after the investigation is finished and the requirements of the VLE are clarified. The development objective is to revise the virtual laboratory prototype to suit the general situation of IS graduate education. If any other new functions are required by the VLE for IS graduate education, these new functions will be designed in this stage as well. Finally, how to integrate the virtual laboratory into the VLE is discussed.

4.3.2 Process of developing the virtual laboratory prototype

The process of developing the virtual laboratory prototype is depicted in Figure 6.

The first phase of this part of the development is requirement determination. Though some requirements of the virtual laboratory have been identified in Chapter 3, the detailed requirements are still to be determined. The system environment, in which the prototype will be implemented and evaluated, will be investigated by reviewing the course documents and conversing with the course instructor, system administrator and some other users of the virtual laboratory.

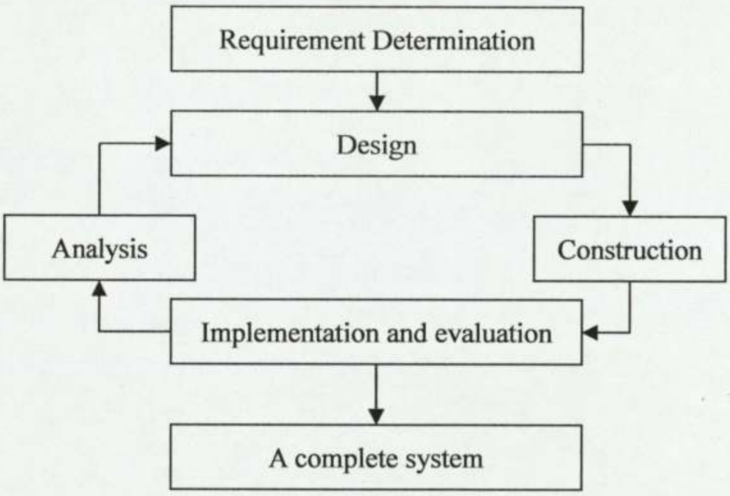

Figure 6. Process of developing the virtual laboratory prototype

After the requirement determination phase, the development will progress through the "prototyping loop". The prototype is developed in an evolutionary approach. The prototyping loop will be repeated until the prototype is considered to be a complete system. In the development of the virtual laboratory, the prototyping loop includes several different rounds which are distinguished according to the different participants who evaluate the prototype. Firstly, the VLE administrator will be invited, then the course instructor, and finally the student. Every prototyping round includes design, construction, implementation and evaluation, and analysis phases.

In the design phase, different models will be designed. A context model and a data model will be designed at first. The context model indicates the whole structure of the prototype, and the data model suggests the relationships of the data. In the different rounds of the prototyping loop, a part of the prototype which will be evaluated by the invited participant of the round will be designed in detail. Thus different models of the prototype will complement each other as the prototype evolves.

In the construction phase, the designed parts of the prototype will be coded. Those parts which have not been designed will be simulated, so that the designed part can be implemented and evaluated.

After the construction phase, the prototype will be implemented and evaluated by different users. The users of the prototype include the VLE administrators, the course instructors and the students. In different rounds of the prototyping loop, different users will be invited to participate in the implementation and evaluation, and the objective of the evaluations will also be different. The evaluation objective will range from clarifying the requirements to verifying the functionality. Various evaluation techniques will be utilised in this phase, including observation of the users' activity, conversation or interview with the users, questionnaires, and system log analysis. The evaluation results will integrate with each other to provide more comprehensive and accurate evaluation results. If the prototype is considered to be ready to implement as a complete system, the prototyping loop will finish and the prototype will be delivered. Otherwise, the prototyping loop will continue to the next phase.

In the analysis phase, the evaluation results and the feedback from users will be analysed. This analysis focuses on revising the requirements of the prototype. According to the result of the analysis, the models will be revised or some new sections of the prototype will be created in the following prototyping loop. After this phase, the prototyping loop will progress to the next round.

Eventually, when the prototype pass all the evaluations, the virtual laboratory prototype will be delivered as a complete system. Though this prototype might only suit the specific environment in which the prototype was developed, it is relevant for the virtual laboratory in a general situation. After necessary revision, the prototype can be improved to meet the requirement of the virtual laboratory of the VLE for IS graduate education.

4.3.3 Process of revising the virtual laboratory prototype and integrating it into the VLE for IS graduate education

As the requirements of the VLE for IS graduate education are being identified, the virtual laboratory prototype can be revised to meet the requirements. Though the virtual laboratory prototype is practical and suitable for the environment in which it is developed, it may not be suitable for the general situation of IS graduate education. The prototype revising aims to meet the requirements of the general situation.

And then, if any new functions for IS graduate education have been identified, they will also be designed. Finally, the virtual laboratory and new functions will be integrated into the current VLE, therefore the current VLE can be converted into a VLE for IS graduate education. The process of this stage of development is depicted in Figure 7.

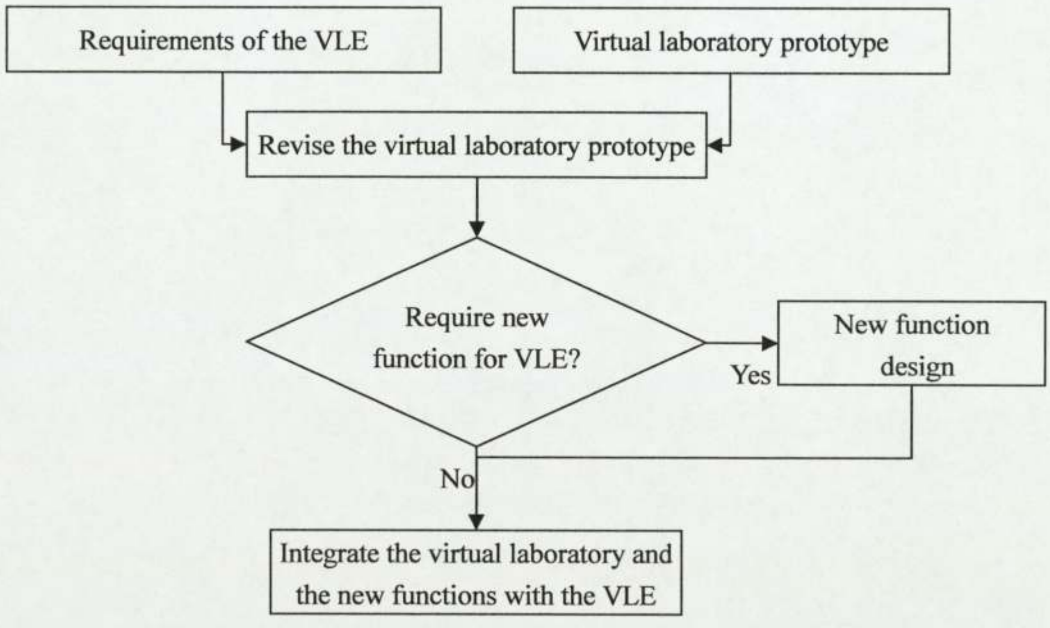

Figure 7. Process of revising the virtual laboratory and integrating it into the VLE

The problems and requirements of the revised virtual laboratory prototype will be analysed, and then the design of the revised prototype will be suggested. Because of the time limitation of the research project as an MSc project, there would not be enough time to implement and evaluate the revised virtual laboratory prototype using real users. The models of the revised virtual laboratory prototype will be drawn to demonstrate the design, then how to integrate the virtual laboratory function into the VLE will be discussed. The models of the integrated system will be suggested. However, as it will not be implemented in a real environment and evaluated by the real users, the practicability and credibility of the research in this stage cannot be confirmed.

4.4 Summary of research methodology

The research project mainly includes the investigation of the situation of IS graduate education and the design of the virtual laboratory to supplement the VLE for IS graduate education. The situation of IS graduate education is investigated by reviewing the webpages of the IS programmes and courses. The samples are from the top business schools in the UK, the US and the Asia Pacific area. A virtual laboratory prototype is developed in parallel with the investigation. After the investigation, the problems and requirements of the VLE for IS graduate education are identified, then the virtual laboratory prototype is revised to suit for the general situation of IS graduate education. The other new functions, if any, required by the VLE for IS graduate education will also be designed. Finally, the virtual laboratory and the other required functions are integrated into the VLE to complete a VLE for IS graduate education.

CHAPTER 5 SITUATION OF IS GRADUATE EDUCATION

5.1 The investigation method

The investigation is to clarify the current situation of IS graduate education, because an accurate understanding of the situation is the prerequisite to designing the VLE for IS graduate education. As discussed in Chapter 2, some in-depth research has been conducted in this area while the broader research is relatively insufficient, so this investigation focuses on the situation of IS graduate education over a broad range. Reviewing the webpages of IS courses and programmes is selected as the main research technique for this part of research. In Chapter 4, the sample selection criteria, data collection methods, and data analysis methods have been discussed briefly. They will be explained in more detail in this section.

In terms of the sample selection of IS programmes and IS courses, as discussed in Chapter 4, the US, the UK, and the Asia Pacific region are the main locations of the samples, so that the author is able to easily and correctly understand the information provided in the webpages for the IS programmes and courses. But the IS programmes and courses in other areas are also relevant if they are of the same high level of quality and can provide the required information in English.

The investigated objectives are the IS programmes and courses in the top business schools. The most effective and efficient way to make the sample list is to group the ranking lists from several famous rankings for the business school or MBA programme in the objective geographic areas. These rankings include: the top 100 full-time international MBA programmes ranking from the Financial Times (FT.com, 2003), the full-time US MBA ranking from BusinessWeek (BusinessWeek.com, 2002), America's best graduate business schools ranking from USNews (USNews.com, 2003), the top 100 universities for business studies ranking from the Times (TimesOnLine.com, 2003), the university guide on business and management studies from the Guardian (EducationGuardian.co.uk, 2003), and Asia's best 100 MBA schools ranking from Asia Week (Asiaweek.com, 2000).

Because of the time limitations of the research project as an MSc project, it is impossible to investigate all the universities listed in the rankings. Another limitation is the number of the samples from different geographic areas. The data analysis and comparison of the differences of different location groups will be easier if the sample numbers from different locations are similar. The investigation samples include the universities in the top 20 of any of the following rankings: Financial Times, Business Week, USNews, the Times and Guardian, and all the universities which are located in Australia, Hong Kong, Singapore or Taiwan in Asia Week's ranking. Overall, 73 universities are included in the sample list: 31 universities are in the UK; 23 universities are from the US; the Asia Pacific group includes 17 universities; and another 2 universities are from locations outside the UK, US and Asia Pacific region. The selected samples are listed in Appendix A. The IS programmes and IS courses in these universities represent the highest quality of IS education. The investigation into the IS programmes and courses in the universities should be able to provide valuable information for the situation of IS graduate education to identify its requirements for the VLE.

The issues on data collection and data recording methods are discussed as follows:

- Full-time on-campus programmes and courses. This investigation aims to identify the requirements of the VLE for IS graduate education. Therefore, the focus of the investigation is certainly the IS programmes and IS courses in the universities. In order to ensure that the quality of the programmes and courses are comparable, the objective programmes and courses are restricted to the full-time on campus master degree graduate programmes.
- MBA programmes. Because it is interesting to study the roles of IS courses in the MBA programmes, the MBA programmes in the investigated universities will also be researched to find out what IS courses are included in their curricula. However, only full-time on-campus MBA programmes and courses will be researched.
- Data to be collected in the investigation. To identify the requirements of the VLE, the most important data is the content and teaching methods of IS graduate education, because these data decide the data format and process of the VLE. To identify the detailed objective of every function of the VLE one needs to know the detailed content and teaching methods of the IS programmes and courses. The content of the courses decides what data format should be supported in the VLE. The teaching methods determine the teaching and learning processes of the VLE and its functions. Moreover, these data can also help to invent some creative teaching

approaches in the VLE.

- Two levels of IS education. This investigation includes two different levels of IS education, the programme level and the course level. Usually a programme is composed of several courses. The courses are the components of the programme. Therefore most of the IS courses are included in the IS programmes. But in some cases, an IS course might be a part of other programmes but not included in any IS programme. For example, a course introducing IS would possibly be a course of the MBA programme but not a course of any IS programme. On the other hand, an IS programme may possibly include some non-IS courses. For instance, an IS programme can include a finance course to provide some business knowledge for the students. In the investigation, only the data of the IS courses are collected and the other non-IS courses in the IS programme, such as the business foundation courses are not included as samples, because they have similar features to the non-IS business courses rather than the IS courses and would not be able to suggest the requirements of the VLE for IS courses. Overall, in the data collection, the IS course data will not only be collected from the IS programmes, but also the other programmes in the targeted business schools will be investigated to find out whether any IS courses are included in these programmes. But the non-IS courses in the IS programme will not be recorded in the research.
- Data from the programme level. Data from the programme level is different from the data from the course level. At the programme level, the programme objective and content are the major data. The objective of the programme is usually presented as a statement on the webpage introducing the programme, so this statement will be recorded in the investigation. The content of the programme might also be found in the programme introduction, yet the content of the programme would be better explained by the curriculum structure of the programme. The programme content can be recorded by finding out what courses are included in the programme, which courses are required courses, and which are elective courses. The programme content can also be classified according to the content focus. An IS programme can be categorised as having an emphasis on technology, an emphasis on business, or a balance between technology and business. This classification can help to summarise the characters of different kinds of IS programmes. Moreover, the programmes are also classified as normal IS programmes, e-business programmes, and MBA programmes. Therefore, the curriculum structure of the programme and the category of the programme will be recorded.

- Data from the course level. At the course level, the objective, content and teaching methods of the course are usually described by some statements in the webpage for the course. Recording these statements is the most simple and accurate way to collect these data. However, these data will be difficult to analyse and compare because they are in text format. One solution is to define some standard content units and teaching methods in advance, and then record which content units and teaching methods are included in the course. This process is actually a coding process. The coding process can be conducted at the same time as the original data collection. This will help to ensure a more accurate coding process, because the coding process is not only based on the original data recorded, but is also based on other data directly found from the data source. Moreover, where the original statement is not comprehensive enough to be coded, more data can be explored to support the coding. The course will be classified as a normal IS course or an e-business course according to the emphasis of the course content, so that the characteristics of normal IS courses and e-business courses can be compared in data analysis. The student numbers of the IS courses are useful to decide the capacity of the VLE. However, the capacity of the VLE would not directly affect the VLE model which is the main objective of the research, and the student numbers are not available on most of the data sources, according to the result of pilot research, therefore the student numbers of the IS courses are not collected in the research.
- Standard content units. The IS model curricula are the ideal sources suggesting the standard content units. Some more content units can be added after the pilot research. From the IS 2002 and MSIS 2000 model curricula, the following content units have been identified:
    - Personal Productivity with IS Technology
    - Introduction to Information Systems Concepts
    - Introduction to Information Technology
    - Introduction to Application Programming and Design
    - Information Systems Theory
    - Information Technology Hardware
    - Networks and Telecommunication
    - Information Technology Software
    - Electronic Business Strategy
    - Electronic Business Architecture and Design
    - Analysis and Logical Design

- Physical Design and Implementation
- Data Design and Management
- Project Management
- Change Management
- IS Policy and Strategy
- Integrating the Enterprise
- Integrating the IS Function
- Integrating the IS Technology

It should be noticed that the last three "integrating" courses include different courses covering IS and other disciplines and some application courses like ERP, SCM. Further details of these courses are given in Chapter 2.

- Standard teaching methods. The following standard teaching methods have been found in the model curricula:
  - Case studies
  - Team projects
  - Laboratory experiments
  - Video
  - Student presentations
  - Individual projects
  - Industry speakers

A pilot research of 10 randomly selected samples has been conducted before investigation on the other samples. The pilot research shows that some webpages of the IS programmes and courses do not provide detailed enough data for the investigation. For example, some webpages only offer the name of the programme or course but no more detailed content information, while some webpages provide information about the objective and the content of the course, but no information about the teaching methods of the course. In the investigation, the author will search related webpages to complete the data. The incomplete data will be excluded in the data analysis. The incomplete information will decrease the comprehensiveness, accurateness and feasibility of the investigation. However, as discussed in Chapter 4, the effect of incomplete data has been considered when selecting the research methods. Reviewing the IS programmes and courses webpages is still the most feasible method for the research project.

Another finding in the pilot research is that the following content units should be added to the standard content units:

- Introduction to electronic business,
- Knowledge management,
- Website design and management,
- Information system research.

Overall, 73 universities are investigated in the research. The following data items will be collected:

- Objective of the programme
- Content emphasis of the programme (emphasis on business, emphasis on technology, or balance between business and technology)
- The type of the programme (MBA, normal IS programme, or e-business programme)
- Objective and content statement of the course
- Teaching methods statement of the course
- Content units included in the course
- Content emphasis on the course (normal IS course, or e-business course)
- Teaching methods used in the course

5.2 Brief description of the data collected

Before describing the collected data, some special cases of the samples should be noted:

- No full-time IS programmes and courses in some universities. According to the data collection rules discussed above, only the on-campus full-time IS graduate programmes and courses will be investigated. Though most of the sample universities provide full-time IS programmes and courses, City University of Hong Kong and Open University of Hong Kong only provide part-time IS programmes and courses, therefore no IS programme or course data are collected from these two universities. In another two sample universities in Hong Kong, Chinese University of Hong Kong and University of Hong Kong, though a small number of full-time IS courses exist, all the IS programmes and most of the IS courses are part-time. Therefore, only limited information about IS education in Hong Kong has been collected in this investigation.

- No IS programmes and courses in the business schools. In the University of Aberdeen and the University of Glasgow in the UK, the business schools do not provide IS programmes and courses. The IS programmes and courses are provided by other schools in the university. Under the data collecting rules discussed above, the IS programme and course not provided by the business school will not be regarded as qualifying samples. Therefore, no IS programme and course data are collected from these two universities.

Therefore, the programme and course data are only from 69 universities out of the 73 sample universities. Because the remaining 4 universities are in fact investigated, and they represent universities having no full-time IS programme or course, or universities having no IS programme or course in the business school, they still count as valid samples in the following data analysis.

The 73 sample universities are mainly from the Asia Pacific area, the United Kingdom, and the United States. Figure 8 shows more detailed information about the location of the sample universities. In the three location groups, the sample from the Asia Pacific region is not as large because not many business schools in this area have a high ranking.

	Number of universities	Percent
Asia Pacific	17	23.3%
UK	31	42.5%
US	23	31.5%
Other location	2	2.7%
Total	73	100.0%

Figure 8. Location of the sample universities

In total 97 graduate programmes are investigated in the research. 15 of them have been classified as e-business programmes because the name of the programme and the statement of objectives directly reflect the fact that they are specially designed to suit the e-business environment. In the investigated universities, 52 MBA programmes have at least one IS course as a required or elective course. Almost all the sample universities have MBA programmes, but some do not provide full-time on-campus

MBA programmes. From every sample university, only the most representative MBA programme is recorded in this investigation. Figure 9 provides some more information about the different groups of programmes found in the research.

	Number of programmes	Percent
E-business programme	15	15.5%
Normal IS programme	30	30.9%
MBA programme	52	53.6%
Total	97	100.0%

Figure 9. Groups of programmes

Altogether 645 IS courses have been found in the sample universities in the investigation. Among these courses, 173 of them are considered to be e-business courses because the name of the course and the objective and content statements of the course directly address the e-business related content. In some courses the e-business content comprises the major part of the course, while in some other courses, for example in the e-marketing course, e-business content is just a part of the whole course. But where the e-business related content is an important component of the whole course, the course will be regarded as an e-business course. The other IS courses which do not include e-business related content are categorised as normal IS courses. Figure 10 shows the detailed information about the groups of the courses investigated in the research.

	Number of courses	Percent
Normal IS course	472	73.2%
E-business course	173	26.8%
Total	645	100.0%

Figure 10. Groups of courses

The research adopts the scope of IS defined in the IS 2002 model curriculum. The details about the definition have been discussed in Chapter 2. Where the course is considered as an IS course, its content will be classified according to different content units. One course might include more than one predefined course unit so the total number of the course units would be more than the number of courses. The "number of courses" in Figure 11 should be explained as the number of IS courses which include the specific content unit. One point that should be noted is that the non-IS courses will not be recorded in the investigation even if it includes one or more course units. For example, a course which discusses knowledge management but does not include any content about using IT in knowledge management will not be recorded in the research. But if the course includes content on how to use IT to manage knowledge, this course will count as an IS course. Figure 11 shows the content classification result of the reviewed courses.

	Number of courses	Percent
Analysis and Logical Design	28	3.5%
Change Management	1	0.1%
Data Design and Management	38	4.8%
Electronic Business Architecture and Design	41	5.2%
Electronic Business Strategy	53	6.7%
Information Systems Theory	40	5.1%
Information Technology Hardware	6	0.8%
Information Technology Software	37	4.7%
Integrating the Enterprise	102	12.9%
Integrating the IS Function	3	0.4%
Integrating the IS Technology	34	4.3%
Introduction to Application Programming and Design	35	4.4%
Introduction to Information Systems Concepts	65	8.2%
Introduction to Information Technology	14	1.8%
IS Policy and Strategy	94	11.9%
Networks and Telecommunication	27	3.4%
Personal Productivity with IS Technology	11	1.4%
Physical Design and Implementation	9	1.1%
Project Management	28	3.5%
Information Systems Research	33	4.2%
Introduction to Electronic Business	49	6.2%
Knowledge Management	25	3.2%
Website Development and Management	17	2.2%
Total	790	100.0%

Figure 11. Classification of course content

The teaching method of the IS course is another main objective of the IS education review. Unlike the course content, not many courses introduce their teaching methods on the webpages. And the name of the course and the programme structure does not imply the teaching methods of the course either. Only when the course provides a clear indication of the teaching methods will the course teaching methods be recorded. Therefore, the credibility of the research on teaching methods is not as high as that on the course content. Classroom lecturing has been assumed to be the default teaching method for the courses and is not recorded as a teaching method in the investigation, because almost all the courses use this teaching method. The details of the classification result of the course teaching methods are indicated in Figure 12.

	Number of courses	Percent
Case studies	46	42.6%
Individual projects	13	12.0%
Industry speakers	11	10.2%
Laboratory experiments	15	13.9%
Student presentations	3	2.8%
Team projects	16	14.8%
Video	4	3.7%
Total	108	100.0%

Figure 12. Classification of teaching method

5.3 Data analysis

This section aims to identify the features of IS graduate education from the collected data. The main issues include the situation of IS graduate education, the situation of e-business education, the role of IS courses in MBA programmes, and the differences among the geographic locations.

5.3.1 Situation of IS graduate education

Having developed for only four decades, the IS discipline is still in its youth. However, the IS programmes and courses play an important role in business schools' graduate education. As shown in Figure 9 and Figure 10, 45 IS programmes and 645 IS courses have been found in the 73 sample universities. On average, every 5 sample business schools would be able to provide 3 full-time on-campus IS graduate programmes, and every sample business school provides 9 IS courses. As indicated in Figure 11, the courses cover a broad range of different content of IS, though there are more courses teaching IS strategy and policy and integrating IS with business activities and fewer courses teaching change management and IT hardware. From Figure 12, case studies are found to be the most popular teaching method for the IS courses. Team projects, laboratory experiments, individual projects, and industry speakers are also frequently used teaching methods in IS education.

Figure 13 describes the content emphasis of the investigated programmes. Perhaps because the investigation is limited within the business schools, few programmes are found to focus on technology. Both the e-business programmes and normal IS programmes are likely to focus on business or to balance the content on both technology and business issues, while the MBA programmes are more likely to focus on the business content.

	E-business programme	Normal IS programmes	MBA programmes	Total
Balance on technology and business	53.3%	46.7%	3.8%	24.7%
Focus on business	46.7%	46.7%	96.2%	73.2%
Focus on technology	0.0%	6.7%	0.0%	2.1%
Total	100.0%	100.0%	100.0%	100.0%

Figure 13. Content emphasis of the programmes

5.3.2 Situation of e-business education

Following the rapid development of the Internet, e-business education has also made great progress in recent years. One third of the investigated IS graduate programmes are e-business programmes. More than a quarter of the reviewed IS courses are e-business courses. These two conclusions from Figure 9 and Figure 10 indicate the important role of e-business programmes and courses in IS education.

Figure 14 shows the course content distribution of the normal IS courses and the e-business courses. The e-business courses include a significantly larger portion of the e-business directly related content units such as electronic business strategy, electronic business architecture and design, and introduction to electronic business. This means that the e-business courses heavily rely on the e-business directly related content.

	Normal IS course	E-busines s course	Total (all IS courses)
Analysis and Logical Design	4.9%	0.0%	3.5%
Change Management	0.2%	0.0%	0.1%

Data Design and Management	6.4%	0.9%	4.8%
Electronic Business Architecture and Design	0.9%	16.1%	5.2%
Electronic Business Strategy	1.1%	21.0%	6.7%
Information Systems Theory	6.7%	0.9%	5.1%
Information Technology Hardware	0.9%	0.4%	0.8%
Information Technology Software	6.0%	1.3%	4.7%
Integrating the Enterprise	12.5%	13.8%	12.9%
Integrating the IS Function	0.5%	0.0%	0.4%
Integrating the IS Technology	5.5%	1.3%	4.3%
Introduction to Application Programming and Design	5.5%	1.8%	4.4%
Introduction to Information Systems Concepts	10.1%	3.6%	8.2%
Introduction to Information Technology	1.9%	1.3%	1.8%
IS Policy and Strategy	14.0%	6.7%	11.9%
Networks and Telecommunication	3.9%	2.2%	3.4%
Personal Productivity with IS Technology	1.9%	0.0%	1.4%
Physical Design and Implementation	1.6%	0.0%	1.1%
Project Management	4.8%	0.4%	3.5%
Information Systems Research	4.8%	2.7%	4.2%
Introduction to Electronic Business	0.5%	20.5%	6.2%
Knowledge Management	4.2%	0.4%	3.2%
Website Development and Management	1.2%	4.5%	2.2%
Total	100%	100%	100%

Figure 14. Cross-tabulation of content unit and course groups

However, as depicted in Figure 15, the character of emphasis on e-business directly related content is not shown on the content distribution of e-business programmes as significantly as that at the course level. Though the several e-business content units are still the major content of the e-business programme, the percentage of other IS content is increased. This indicates that the e-business programmes not only include e-business content, but also include a lot of normal IS content. This content can broaden the knowledge coverage of the e-business programme and provide relevant knowledge for e-business programme students.

	E-business programmes	Normal IS programmes	MBA programmes	Total
Analysis and Logical Design	0.6%	6.3%	2.2%	3.6%
Change Management	0.0%	0.0%	0.4%	0.1%
Data Design and Management	3.4%	5.4%	3.7%	4.4%
Electronic Business Architecture and Design	11.3%	0.9%	5.9%	4.9%
Electronic Business Strategy	8.5%	1.7%	9.2%	5.8%

Information Systems Theory	4.5%	8.0%	3.7%	5.8%
Information Technology Hardware	1.7%	0.6%	0.7%	0.9%
Information Technology Software	5.6%	8.9%	1.8%	5.8%
Integrating the Enterprise	10.2%	10.9%	14.4%	11.9%
Integrating the IS Function	0.6%	1.1%	0.4%	0.8%
Integrating the IS Technology	4.0%	5.7%	1.1%	3.8%
Introduction to Application Programming and Design	4.5%	6.6%	3.3%	5.0%
Introduction to Information Systems Concepts	2.3%	4.3%	12.2%	6.5%
Introduction to Information Technology	2.3%	0.9%	3.7%	2.1%
IS Policy and Strategy	11.3%	13.8%	12.2%	12.7%
Networks and Telecommunication	9.0%	4.0%	3.0%	4.8%
Personal Productivity with IS Technology	0.0%	0.9%	1.1%	0.8%
Physical Design and Implementation	0.0%	2.0%	0.7%	1.1%
Project Management	1.7%	4.9%	3.0%	3.5%
Information Systems Research	5.1%	6.6%	0.4%	4.1%
Introduction to Electronic Business	7.3%	1.7%	10.3%	5.9%
Knowledge Management	1.1%	2.9%	4.8%	3.1%
Website Development and Management	5.1%	2.0%	1.8%	2.6%
Total	100.0%	100.0%	100.0%	100.0%

Figure 15. Cross-tabulation of content unit and programme groups (% within programme group)

In terms of the teaching methods, laboratory experiments and team projects play a more important role in the e-business courses than in the normal IS courses. The e-business courses use noticeably more laboratory experiments compared to the normal IS courses. This might indicate that the e-business courses are more concerned with practical issues. More details are shown in Figure 16.

	Normal IS course	E-business course
Case studies	41.3%	44.4%
Individual projects	14.3%	8.9%
Industry speakers	12.7%	6.7%
Laboratory experiments	9.5%	20.0%
Student presentations	3.2%	2.2%
Team projects	12.7%	17.8%
Video	6.3%	0.0%
Total	100.0%	100.0%

Figure 16. Cross-tabulation of teaching methods and course groups (% within course group)

As shown in Figure 17, the usage of teaching methods for the e-business programmes is similar with that for the e-business courses. Case study, laboratory experiment, and team project are the most frequently used teaching methods for the e-business programmes.

	E-business programmes	Normal IS programmes	MBA programmes	Total
Case studies	32.4%	38.2%	45.7%	39.5%
Individual projects	11.8%	20.6%	4.3%	11.4%
Industry speakers	2.9%	11.8%	13.0%	9.6%
Laboratory experiments	20.6%	14.7%	8.7%	14.0%
Student presentations	2.9%	2.9%	2.2%	2.6%
Team projects	23.5%	5.9%	19.6%	16.7%
Video	5.9%	5.9%	6.5%	6.1%
Total	100.0%	100.0%	100.0%	100.0%

Figure 17. Cross-tabulation of teaching methods and programme groups (% within programme group)

Overall, by summarising the analysis at both course level and programme level, e-business education has two significant features. One feature is that e-business programmes and courses include a larger percentage of e-business directly related content than the normal IS programmes and courses. The other feature is that case studies, laboratory experiments, and team projects are the main teaching methods for e-business education. Laboratory experiments are more frequently used in e-business programmes or courses than in other IS programmes or courses.

5.3.3 The role of IS courses in MBA programmes

From every sample university, only one full-time on-campus MBA programme will be recorded in the investigation. 52 MBA programmes which provide at least one IS course have been recorded in the research. So this means that in the 73 investigated universities, 52 universities provide a full-time on-campus MBA programme which includes at least one IS course. Among the 645 IS courses, 228 courses are part of MBA programmes. 16.2% of these courses are required courses of the MBA programmes. The rest are elective courses. The detail is shown in Figure 18.

	Number of courses	Percent
Required course of MBA programme	37	16.2%
Elective course of MBA programme	191	83.8%
Total	228	100.0%

Figure 18. IS courses in MBA programme

As suggested by Figure 19, among the 52 MBA programmes, 25 programmes, which is almost half of the recorded MBA programmes, have IS courses as required course. More programmes have IS courses as elective courses. Moreover, if we assume that all the 73 sample universities have full-time on-campus MBA programmes, more than 70% of their MBA programmes provide IS courses. About one third of them would even have an IS course as a required course. This indicates the important role of the IS course in MBA programmes.

	Number of MBA programmes	Percent of MBA programmes	Percent of sample universities
Provide IS course	52	100%	71.2%
Provide IS course as required course	25	48.1%	34.2%
Provide IS course as elective course	42	80.8%	57.5%

Figure 19. MBA programmes having required/elective IS courses

In terms of the content of the IS courses in the MBA programmes, as shown in Figure 15, the course content focuses on the introductory knowledge of IS and e-business, the strategy of IS and e-business, and integrating IS with enterprise functions. This means that the IS courses in MBA programmes focus on the background knowledge of IS and e-business and how to integrate IS and e-business into business strategy. The teaching methods of the IS course in MBA programmes focus on case studies, team projects, and industry speakers, as suggested by Figure 17.

5.3.4 The differences among the geographic locations

In the research, the sample universities are mainly from three locations: Asia Pacific, the United Kingdom, and the United States. The development of IS education in different locations shows variations. It would be an interesting question to identify the differences of IS education among the different geographic locations.

Figure 20 describes the relationship of the programme groups and geographic locations. The number in the figure means the average number of programmes provided by an investigated university from different geographic locations. The "MBA programme" line in the figure means MBA programmes which provide at least one IS course in their curriculum in the investigated universities. The universities in the Asia Pacific area provide significantly more IS programmes, whether e-business programmes or normal IS programmes, than the universities in the UK and the US. The sample universities in the US provide much fewer IS programmes than the universities in the other two locations but they provide more MBA programmes with IS courses.

	Asia Pacific	UK	US
E-business programme	0.41	0.23	0.04
Normal IS programme	0.82	0.42	0.13
MBA Programme	0.47	0.65	0.96

Figure 20. Means of programmes provided by sample university number in different locations

At the course level, as shown in Figure 21, the percentages of normal IS courses and e-business courses in all IS courses are similar among the three location groups, though the universities in the UK provide a slightly higher percentage of e-business courses and a lower percentage of normal IS courses.

	Asia Pacific	UK	US	Total
Normal IS courses	75.7%	64.7%	77.0%	73.2%
E-business courses	24.3%	35.3%	23.0%	26.8%
Total	100.0%	100.0%	100.0%	100.0%

Figure 21. Cross-tabulation of course type and location (percent of all IS courses)

As indicated in Figure 22, on average an MBA programme in the US provides 5.86 elective IS courses, and an MBA programme in the Asia Pacific area provides 4.5 elective IS courses, but an MBA programme in the UK provides only 1.45 elective IS courses which is much fewer than the other two locations. Moreover, the MBA programme in the Asia Pacific area requires the students to take 1.25 IS required course on average, which is much higher than the programmes in the other two locations.

	Asia Pacific	UK	US
Required course of MBA programme	1.25	0.5	0.55
Elective course of MBA programme	4.5	1.45	5.86

Figure 22. Mean of IS courses in an MBA programme in different locations

5.3.5 Summary of the data analysis results

The IS programmes and courses have been playing an important role in business schools' graduate education. The IS programmes in the investigated business schools mainly focus on business issues or balance on technology and business issues of IS. Case studies, team projects, laboratory experiments, individual projects and industry speakers are the most frequently used teaching methods in the IS courses.

The e-business programmes and courses are one of the important components of IS education. The e-business courses mainly focus on e-business directly related content, such as introduction to e-business, e-business strategy, and e-business architecture and design, while the e-business programmes will also include a broad range of courses from other areas. Case studies are the most frequently used teaching method in e-business education. Laboratory experiments and team projects are more frequently used in the e-business programmes and courses than in the normal IS programmes and courses.

Nearly half of the investigated MBA programmes have an IS course as a required course. In the investigated universities, more than 70% of MBA programmes provide IS courses. The IS courses should be regarded as an important part of the MBA programmes. The IS courses provided by the MBA programmes focus on the introduction to IS and e-business, the strategy of IS and e-business, and integrating IS with enterprise functions. The frequently used teaching methods for these IS courses include case studies, team projects and industry speakers.

More IS graduate programmes have been found in the Asia Pacific area and in the UK. The MBA programmes in the Asia Pacific area have more required IS courses, while the MBA programmes in the UK provide fewer IS courses as elective course.

Apart from the above findings, plenty of information for identifying the problems and requirements of the VLE for IS graduate education was also found during the investigation. In Section 5.5, this information will be analysed to identify the requirements of the VLE for IS graduate education.

5.4 Discussion on the investigation

Though the Internet has been broadly accepted as an information source for research, most research still only uses it as the secondary data source. The information collected from the Internet is not usually used as the primary data in research (Saunders, *et al.*, 2000). However, in this research project, reviewing the IS education webpages has been utilised as the primary data collection method. The following are some interesting experiences from this investigation:

- Searching for complete data. By using this research method, the author has to be very active in hunting the data from different webpages. It is impossible to look through all the webpages of the investigated university, because every university provides a great amount of information on the webpages. A good strategy for searching the data is necessary for this investigation. Several questions have been considered to decide the strategy. The first question is the complete level of data required for the investigation. In this research, the complete IS education data for a university should satisfy three criteria: a complete list of the IS programmes, a complete list of the IS courses, and comprehensive enough data to classify the content and teaching methods of the course. The second question is how to search for the data. For each university, the investigation will focus on three kinds of webpages: the webpages introducing the programmes provided by the university, the webpages introducing the programmes provided by the business school, and the webpages introducing the programmes and courses provided by the IS department or research group. Because the complete list of IS programmes and courses is most likely to be described in these webpages, and the more detailed information on the programmes and courses is usually linked to these webpages, reviewing these webpages first helps to save time. Searching the data from different sources also enables the author to double-check the credibility of data.

- Dealing with conflicting information. When collecting the data from three different levels - university, school and department - at the same time, conflicting information might be found. This problem occurs when the information is not updated at the same speed. In such a situation, the author will try to find out which page is the most updated one and select this one as the accurate data source.
- Classifying the course content and teaching methods. In order to facilitate the data analysis, the course content and teaching methods will be classified when the course information is collected. Deciding the teaching methods utilised in the course is relatively simple. If the course information includes the teaching methods statement, the teaching methods names are usually listed in the statement. But the course content units included in the course could be very confusing in some cases. The course content can be reflected from the name of the course and from the statements about the objective and content of the course. However, the content statement is usually described at a more detailed level than the standard content units. The author has to read the content statement carefully and identify what content units are included in the course. Moreover, sometimes the course names do not present the expected course content. An example from the investigation is that a course named "Electronic Commerce Fundamentals" and a course named "Internet Technologies" both only teach webpage development. Without a detailed investigation on the course content statement, these two courses might be wrongly classified into "Introduction to E-Business" and "Network and Communication Technology". Coding the data at the same time as collecting the data is valuable to minimise the effect of the confusion on course content. Because the author has the best understanding towards the scope of the predefined course units, when the information of the course content is not clear enough, the author can put more effort towards finding the more detailed information. When the information is detailed enough, the author can make the most correct decision of the classification immediately, so the time spent getting more comprehensive information can be saved.

Overall, many strategies and techniques have been utilised in the investigation in order to ensure the credibility of the research. The investigation result indicates that reviewing the webpages has enabled the collection of adequate data for the research project.

5.5 Requirement identification of the VLE for IS graduate education

As discussed in Chapter 1 and Chapter 4, the requirement of the VLE for IS graduate education will be identified based on 1) the literature review on IS graduate education and VLE, and 2) the investigation into the situation of IS graduate education. Because the literature review have covered previous in-depth research in IS graduate education and VLE, they should be able to suggest most required functions of the VLE for IS graduate education. The investigation result can confirm the requirement identification, and perhaps can suggest some more requirements of IS graduate education. In the following section, the requirement will be identified by utilizing a common VLE requirement identification framework firstly based on the information from the literature review. Then, the literature review will be analyzed to find out the other requirements.

5.5.1 Identification framework

The requirements can be identified from two aspects. The first relates to how to reuse the learning resources and teaching methods in the traditional learning environment. The second aspect relates to how to employ the advantage of the Internet and IT in the VLE. Both of the analysis aspects have commonly been used in previous research into the requirements of VLEs (e.g. Cloete, 2001; Ismail, 2002).

It is very important for the universities to reuse the learning resources and teaching methods in the VLE. Most universities have a long history of educating in the traditional learning environment. They have accumulated rich learning resources and abundant experience of employing teaching methods in the traditional environment. If the VLE cannot reuse these learning resources and teaching methods, it would be a huge waste for the universities.

At the same time, the VLE for IS graduate education should employ the advantages of IT. The advantage of IT is the main reason for universities to employ the VLE. The VLE should be able to overcome the limitation of space and time in the traditional learning environment. The VLE should also be able to make use of the rich information in the Internet, and be able to reflect the latest development in the learning area. Facilitated by the advanced technologies, the VLE should provide novel educational approaches for the instructors and students.

5.5.2 Requirement identification

The requirement identification will first identify the requirements as to how to reuse the learning resources and teaching methods in the VLE. And then the requirements as to how to present the advantage of the Internet and IT will be discussed.

IS graduate education uses a broad range of learning resources. These learning resources range from paper-based books and journals to online journal databases and online libraries, from the PowerPoint document created by the instructors to the complicated Enterprise Resource Planning (ERP) software system. To reuse these learning resources, the VLE needs to have the functions to store the resource and represent it. The VLE should have virtual learning places to reproduce the learning places of the traditional learning environment, and the traditional learning resource can be stored and used in the corresponding learning places in the VLE. Therefore, the virtual classroom, virtual library, virtual laboratory, virtual discussion room, virtual exam room, and virtual rest room should be included in the VLE.

Compared with the reuse of the traditional learning resources in VLE, reusing the teaching methods is more difficult. The main teaching methods for IS graduate education include classroom lecturing, case studies, laboratory experiments, individual projects, team projects, industry speakers, student presentations and video. They should be employed conveniently in VLE.

Classroom lecturing, industry speakers, student presentations and video can be regarded in the same group of teaching methods in VLE. They all have a main information provider, and the teaching activity is mainly controlled by this information provider. The virtual classroom is designed to support this kind of learning activity. In the virtual classroom, video/audio broadcasting is needed to deliver the images and/or sound of the lecturer. In the traditional IS classroom, the PowerPoint slides are frequently used, so the PowerPoint slide show function is needed in the virtual classroom. Sometimes the lecturer will show some webpages and pictures, or demonstrate some software programmes in the traditional IS classes, therefore the sharable Web tour, sharable whiteboard, and application sharing functions which can support these learning activities are required in the virtual classroom. Moreover, simulation tools are also required in the virtual classroom.

Case studies is regarded as a highly important teaching method for IS graduate education. In the VLE a virtual discussion room is required to support this teaching method. When case studies is used, every participant is an information provider, and everyone controls his/her own learning activity. The virtual discussion room should provide multipoint video/audio and a text discussion board to support the case study. The other functions, such as PowerPoint slide show, sharable Web tour, sharable whiteboard, and application sharing, should also be available in the virtual discussion room. A simple discussion support system should be included in the virtual discussion room to facilitate the discussions. Moreover, the virtual discussion room should support both asynchronous and synchronous discussion.

Laboratory experiments, individual projects and team projects require virtual laboratory function to support them. Facilitated by the virtual laboratory, students do not have to go to the traditional computer laboratory to perform the experiments. Instead, they can use any computer with an Internet connection to visit the virtual laboratory. Moreover, some simple functions on project management should also be included in the VLE in order to better support individual projects and team projects. These functions include calendar arrangement and task assignment.

The investigation into the situation of IS graduate education can also confirm that the VLE for IS graduate education requires above functions. All the teaching methods and teaching contents found in the investigation can be supported by the VLE with above functions. However, the investigation result suggests that the virtual laboratory function should be enhanced in the VLE for IS graduate education. In the investigation, laboratory experiments, individual projects and team projects are identified among the most frequently used teaching methods in IS graduate programmes and courses. Virtual laboratory is more important in the VLE for IS graduate education than in the other VLEs. Virtual laboratory should also facilitate the students' self-studying and communication, and provide assessment for the learning efficiency. However, there are some experiments cannot be supported by virtual laboratory, such as the experiments on computer hardware and on network connection. Therefore, the VLE should provide some simulation tools for this kind of experiments.

After the requirement identification from the aspect of reusing the learning resources and teaching methods, the requirement identification turns to the aspect of utilising the advantage of IT and the Internet.

For the VLE, the most valuable advantages of IT are that they can overcome the limitation on time and space; they can automatise the processes; and they can improve communication and collaboration.

Overcoming the limitation on time and space is the most important and basic character of the VLE. It is the main reason why universities employ the VLE in teaching and learning. The student is able to study anytime and anywhere through the VLE.

IT can automatise the student's leaning process in the VLE. An intelligent instruction agent should be included in the VLE. This intelligent instruction agent can monitor the students' learning activities and provide learning suggestions for the students. It acts as a personal supervisor for the students to guide them to learn effectively and efficiently.

The VLE can also provide a variety of functions to facilitate communication and collaboration among the VLE users, including the instructors and students. These functions include notice board, E-mail, instant message, file exchange, sharable whiteboard, shareable Web tour, and application sharing. The users should be able to use these functions anytime and anywhere within the VLE.

5.5.3 The function model of the VLE for IS graduate education

By summarising the above requirements, the function model of the VLE for IS graduate education is drawn as Figure 23. In this function model, the functions are categorised into three groups: virtual learning places, studying arrangement tools, and communication tools. The learning spaces reproduce the traditional learning places in the VLE. The studying arrangement tools aim to facilitate the arrangement of the students' learning activities. The communication tools aim to provide a service for communication and collaboration among the users.

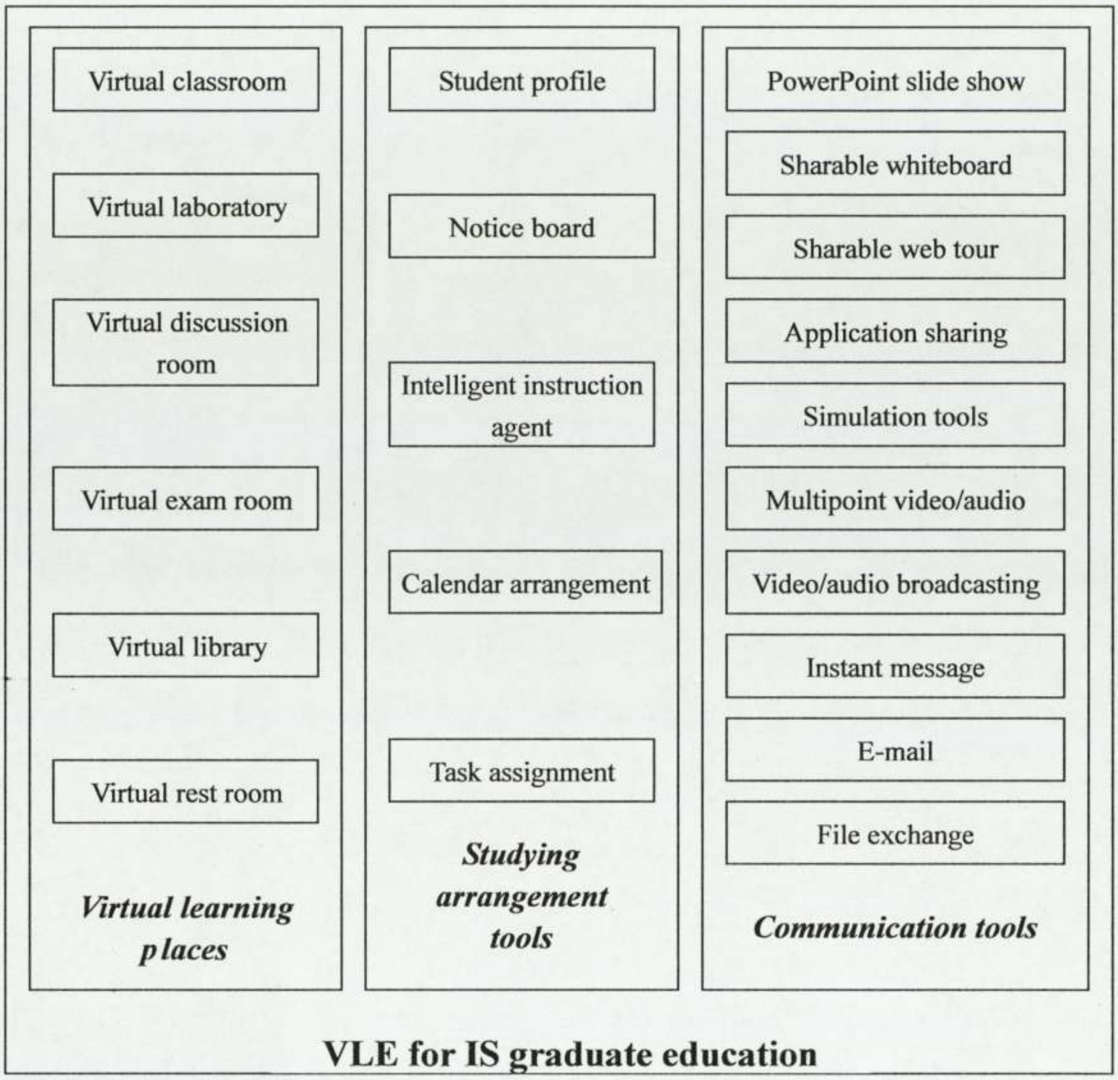

Figure 23. The function model of the VLE for IS graduate education

The functions in the "virtual learning places" group reproduce the different places of the traditional campus in the VLE. The learning resources can be stored in these virtual learning places. Most of the traditional teaching methods still can be employed in these virtual learning places. The instructors can design and manage the learning resources, and the students can access them in these virtual learning places.

The "studying arrangement tools" group is designed to help the students to arrange their study activities. The student profile function will not only store the personal information of the student, but also store the learning activities and learning performances of the student. The notice board will broadcast information for the students. The task assignment and calendar arrangement tools can arrange the learning activities for the user. They can also be shared with other students and the instructors under authorisation, so that they can be utilised as simple project management tools. The intelligent instruction agent will act as the student's personal supervisor to provide suggestions for the students according to their learning progress. This is a special feature of the VLE, compared with the traditional learning environment. In the traditional learning environment, it is very difficult to provide personal instruction advice for every student. But developments in IT make it possible in the VLE. Many researchers have been working in this area to design the intelligent instruction agent.

The communication tools function group includes different tools to facilitate communication and collaboration among the users. One special feature of these functions is that they can be used in any virtual learning places and cooperate with the other functions in that virtual learning place.

In summary, the VLE for IS graduate education should comprise all the functions listed on the function model. By reviewing the previous research, all of the functions except the virtual laboratory function are found in the current VLEs, though some of the functions might not suit IS education very much. Therefore, the virtual laboratory should be developed to supplement the VLE for IS graduate education.

CHAPTER 6 VIRTUAL LABORATORY

6.1 The virtual laboratory prototype

As discussed in Chapter 4, the system development process of the virtual laboratory includes two main stages. The first stage is to develop the virtual laboratory prototype. The second stage is to revise this virtual laboratory prototype to suit the requirements of the general situation and then to integrate the virtual laboratory into the VLE for IS graduate education.

The virtual laboratory prototype is developed through the RAD system development approach. The development begins with an accelerated requirement determination phase which identifies the basic requirements of the prototype. Then, the development will proceed to the "prototyping loop". A working prototype will be designed, constructed, implemented, and evaluated in the prototyping loop until it becomes a complete system. In this development stage, the system development is an evolutionary construction process of the working prototypes.

If the system development is described by time order, the readers might be confused by the different versions of prototypes with the final version of the virtual laboratory. In order to make the development of the prototype understood more easily, the system design process will be described based on the different development phases but not on the prototyping rounds. The description emphasises the final result of the system design, while the research results in different prototyping rounds will also be mentioned.

6.1.1 The problems and requirement analysis

As described in Chapter 4, the prototype is developed in parallel with the investigation on IS graduate education. The requirements of the VLE for IS graduate education are not yet identified during the prototype development. Therefore, the prototype needs to identify its own problems and requirements.

The virtual laboratory prototype utilises RAD as the developing method. This research method does not demand very detailed requirements before the development begins. The detailed requirements can be identified during the system implementation and user evaluation. However, in order to simplify the description of the problem and requirement analysis, the analysis discussed in the following includes the problems and requirements identified before the system design begins, and those identified during the system implementation and evaluation.

The prototype development is conducted in Aston Business School. Aston Business School is one of the top business schools in the UK. A range of MBA and MSc programmes are provided at the graduate level. Different IS courses are offered as the required or elective courses in these programmes. The school selects Blackboard as the VLE to support teaching and learning. The instructors use the VLE to provide course information for the students and to communicate with the students. The students utilise the VLE to access the learning materials and to communicate and collaborate with the instructors and other students. The VLE is becoming an important tool to facilitate the delivery of knowledge.

However, the VLE – Blackboard – cannot help the students to conduct the IS experiments through the Internet. The virtual laboratory prototype aims to supplement this missing function for the VLE. More specifically, it aims to support a graduate e-business strategy course which has some experiments on an ERP system - Caliach Vision.

The e-business strategy course is a core course in IS graduate education. It requires the Caliach Vision experiments to demonstrate the ERP system and to provide a chance for the students to experience an ERP system. This kind of demonstration experiment is the most common experiment in IS graduate education. Caliach Vision is an ERP system with a relatively user-friendly interface. Though Caliach Vision is a simplified ERP system, its system requirements are still stricter than many other information systems. Selecting this course and experiment as the sample situation makes the requirements of the prototype can represent most IS experiments. Selecting Caliach Vision as the sample software increases the prototype compatibility requirements, and avoid the influence from the software user-interface during the prototype evaluation.

Though Caliach Vision has been acquired, there are still some practical difficulties preventing the students from experiencing the system. The main problems are listed as follows:

- User licenses. The school only has 5 user licenses for Caliach Vision. It is impossible for the whole class of students to experience the system at the same time. If every student is assigned a short period of time to use the system, the students who are interested in the system might not have enough time to explore the system.
- Managing the system data. A variety of data should be input into Caliach Vision before the system functions can perform effectively. Different data in the system will result in different output. The data stored in the system must be the same as the original data whenever a new user begins the experiment so that the students can get consistent output and be sure that they have performed a correct operation. Therefore, when a user finishes using the system, the system data should be restored to the original data.
- Frequent system update. Caliach Vision is updated frequently. Some updates are to fix the bugs and some others are to add new functions. Every update requires reinstalling the system and sometimes converting the data files into a new format. If the system has been installed in a broad range of computers, the update process could be very time-consuming.
- Assessing the learning performance. As shown in the previous research on the experiments in IS education, the learning performance of the ERP system experience is difficult to assess. It makes the assessment more difficult when the data files need to be restored.

The virtual laboratory prototype should provide a sound solution for this experiment. From the above problem analysis and the general features of the VLE, the required features of the virtual laboratory prototype are identified as follows:

- Web-based. Web-based has become a standard feature for VLEs. The Web-based virtual laboratory should be able to be accessed anytime anywhere. This can significantly increase the flexibility of conducting the experiments. The students do not have to go back to the campus to access the software system. They can choose to conduct the experiments at a convenient time in a convenient place. Learning to operate Caliach Vision will still need a great amount of time. The flexible time arrangement makes it easier for the students to arrange enough time to learn the system. The flexibility of experiment time also provides more chances for the students to explore the advanced features and functions of Caliach Vision which are not included in the experiment. Moreover, the Web-based feature enables this prototype to be integrated into the VLE easily. The VLE can redirect the students to the virtual laboratory prototype by just adding a webpage link. The user interface of the virtual laboratory prototype can be revised to suit the VLE so the virtual laboratory user interface can also be integrated into the VLE user interface easily.

- A comprehensive experiment guide. Because of the difficulties on learning Caliach Vision, a comprehensive guide for the students to conduct the experiments is necessary. This guide should be straightforward enough so that the students can follow it to conduct the experiments step by step. This guide should be displayed in a noticeable place in the user interface of the virtual laboratory prototype. It would be even better if the guide always stays on the top of the screen, so that the students can easily find the experiment guide and follow it to accomplish the experiments.
- Represent the real system interface by Terminal Service. Since Caliach Vision does not provide a Web-based user interface, it cannot be accessed directly from the Web. There are two methods to make it possible to operate the system through the Web. One solution is to design a Web-based user interface for the system. But this design process is very complex and risky, because this target can be achieved only when the developer is very familiar with every technical detail of the system. This Web-based interface design also requires excellent skills. Therefore, this solution is not feasible to develop the virtual laboratory. The other solution is to utilise the Terminal Service technology. Terminal Service, which is named as Remote Desktop Service in the Win XP platform, is a technique which enables the client computer to remotely control the server. The user can use a client computer to connect to the server through the Internet and then operate the server by using the Terminal Service. The display of the server's screen can be mirrored to the client computer. Though all the application execution, data processing, and data storage still occur on the server, the user operates the client computer and sees the server's screen on the client computer, so user controls the server just like he is controlling his own client computer. Moreover, each user can only see their individual session which is managed transparently by the server's operation system and independent from any other client session in the server (Microsoft, 1999). Therefore, several users can use the same server at the same time but the user's operation would not be effected by the other users. Microsoft also provides an ActiveX control named Terminal

Services Advanced Client which can employ Terminal Service in the browser (Microsoft, 2000). By embedding the Terminal Services Advanced Client in the virtual laboratory prototype webpage, the virtual laboratory prototype webpage will be able to support the user to connect to the Terminal Service server, see the server's screen just as seen on the server monitor, and operate the software installed on the server. This technique provides a sound solution which allows the students to conduct the Caliach Vision experiments through the Web-based virtual laboratory prototype.

- Integrate the Terminal Service screen with the experiment guide. The Terminal Service client needs a relatively large screen area to display the application screen, while the experiment guide needs to stay on the top of the screen so that the users can check the guide anytime they need. This conflict of competing use of the screen area requires a good user interface design for the virtual laboratory prototype.
- Assessment tools. Some assessment tools should be added into the virtual laboratory prototype to facilitate the education process. The assessment tools should be able to provide the information on the virtual laboratory usage, the students' experiment performance, and some other information. Some exercises or quizzes should be embedded in the experiment process to investigate the student's learning performance and provide feedback to the students.
- License control. The Web-based system enables the students to use Caliach Vision anytime anywhere. It is possible that many users use the system at the same time. However, the user number of Caliach Vision is restricted to five due to the license fee. Therefore, the virtual laboratory prototype should have the license control function to manage the number of users accessing Caliach Vision simultaneously. By controlling the user number, the workload of the application server on which Caliach Vision runs can also be controlled.
- Security control. Delivering the experiment through the Internet will mean risks from hackers, viruses and other attacks. The Terminal Service needs to allow the users to log on to the server through the Internet. This will put the server in an even more risky environment. The virtual laboratory prototype has to ensure the server's security and stability. A multilevel authorising mechanism will be employed in the virtual laboratory prototype to provide better protection for the system. The server's security setting should also be enhanced.
- Data file control. The virtual laboratory prototype should be able to restore the data file after the user finishes the experiment and manage the data file left by the users who are disconnected from

the virtual laboratory because of system or network errors.

In summary, the virtual laboratory prototype aims to support the students to conduct the experiment on Caliach Vision through the Internet. The prototype should be Web-based, provide a comprehensive experiment guide and a variety of assessment tools. The Terminal Service technology will be employed in the virtual laboratory prototype to allow the users to operate the system installed on the server. Moreover, the virtual laboratory prototype should have license control, security control and data file control functions.

6.1.2 The design of the prototype

After identifying the requirements of the virtual laboratory prototype, the development proceeds to design the prototype. The design phase includes logical design and physical design.

The logical design begins by discussing the data involved in the prototype, and then it proceeds to consider the process of the virtual laboratory prototype, including how the user operates and how the data flows. Entity relationship diagrams and data flow diagrams will be utilised to explain the logical design. Entity relationship diagrams depict data in terms of the entities and relationships described by the data (Whitten, *et al.*, 2001). It is usually used to explain the data design of a system because it can clearly describe what data is involved in the system and what the relationships of the data are. On the other hand, data flow diagrams depict the flow of data through a system and the work or processing performed by that system (Whitten, *et al.*, 2001).

The entity relationship diagram for the virtual laboratory prototype is depicted in Figure 24. Five tables, which are named as users, licenses, logs, assessment results, and assessment questions, are included in the database of the virtual laboratory prototype. The "PK" in the entity relationship diagram means "primary key", which indicates that the data field can be used to distinguish every unique data record. The "FK" in the diagram means "foreign key", which indicates that the data field has connection with the data field in other table.

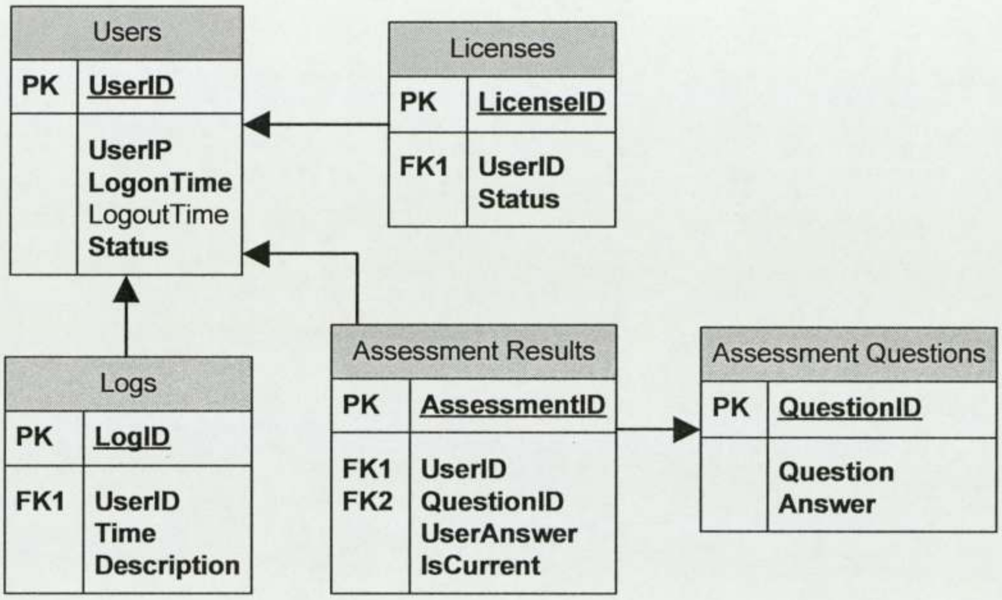

Figure 24. Entity relationship diagrams of the virtual laboratory prototype

In the virtual laboratory, the user data is the most important data. The user data not only provides information on the user activities, but also connects the other data records. For an independent virtual laboratory prototype, it would be a more ideal design to create a user record for every potential user in advance. However, because the virtual laboratory prototype is designed as a supplement of the VLE for IS graduate education, and the VLE can provide the user record for the virtual laboratory after the prototype is integrated into the VLE, the user record management function is simplified in the virtual laboratory prototype. A new user record is created in the virtual laboratory prototype whenever a user logons the virtual laboratory. The user will be associated to this user record until he logouts the virtual laboratory.

Because the virtual laboratory prototype needs to control the user licenses, the license data is also necessary to be included in the virtual laboratory prototype. The licenses data is mainly used to check whether or not there is a user license available for the new user when the user logons the virtual laboratory.

The assessment questions and assessment results data are utilised to facilitate the assessment. The assessment question records can provide a collection of questions for the virtual laboratory prototype. The assessment results data records the assessment results of the students in the virtual laboratory prototype.

The user's activity and the system response will be recorded in the log records. The log data is involved in the prototype because it can provide valuable information for investigating whether the prototype performs correctly. The log data will also be useful to investigate the user behaviour in the virtual laboratory prototype.

Overall, the users, licenses, assessment questions, assessment results, and user logs data are included in the prototype.

While the entity relationship diagram depicts the data involved in the virtual laboratory prototype, the data flow diagram depicts the flow of data and the processing in the prototype. Figure 25 is the context data flow diagram of the prototype. It depicts the relationships of the virtual laboratory prototype and its main interfaces. "Experiment Guide" is a data store of the prototype which provides the experiment guide data for the prototype. The "User" and "Caliach Vision" are the main interfaces of the prototype. The most important operation of the virtual laboratory is to provide the experiment guide for the user, transmit the user's operation to Caliach Vision and then transmit the operation results back to the user. The virtual laboratory also provides the assessment for the users and provides other services such as license control, security control, and data file management. Because these processes are not the most important function, they are not shown in this context data flow diagram.

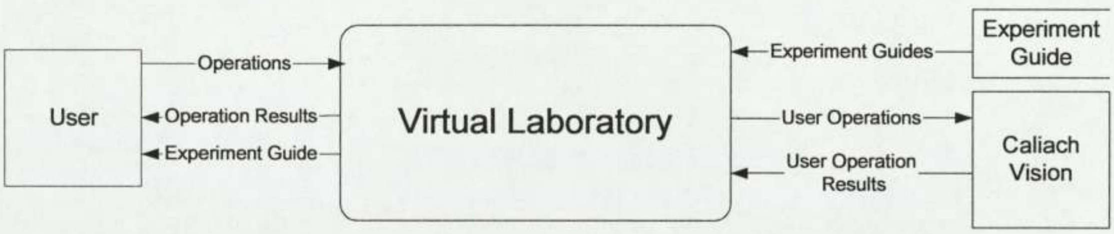

Figure 25. The context data flow diagram of the prototype

The event data flow diagrams are used to explain the detailed processes of the prototype. The main events in the virtual laboratory include user logon, user logout, user disconnect, system disconnect, and assessment. Most of the functions of the virtual laboratory are utilised in these events. The detailed information for each event will be discussed in the following paragraphs.

The user logon event, which is depicted by Figure 26, is performed when the users access the logon webpage of the virtual laboratory. The virtual laboratory firstly checks whether there are any user licenses available, and then the licenses availability information is transmitted to the user. If there are licenses available, the user can select a license and continue the user logon process, otherwise, the user has to wait for a license. The license selected by the user is updated as an occupied license so that other users cannot use this license until the user finishes using the license. The new user record is added to the user data store, and the user logon information is created in logs data store. After logging on the virtual laboratory, the user sees the experiment guide, and the user is able to connect to the Terminal Service server on which Caliach Vision is installed. However, the Terminal Service server also requires the user to input the username and password for the server. This username and password is provided by the course instructor before the users conduct the experiments. This process aims to protect the Terminal Service server better so that the unauthorised users cannot logon the server. After the user logs on the Terminal Services server, the Caliach Vision screen, which mirrors the display of the server's monitor, is shown in the virtual laboratory, and then the users can begin the experiments. The user's activities on Caliach Vision are mainly managed by the Terminal Service. The mouse clicks and keyboard inputs in the Caliach Vision screen are transmitted to the server and Caliach Vision system, and then the response is shown on the Caliach Vision screen. At the same time, the virtual

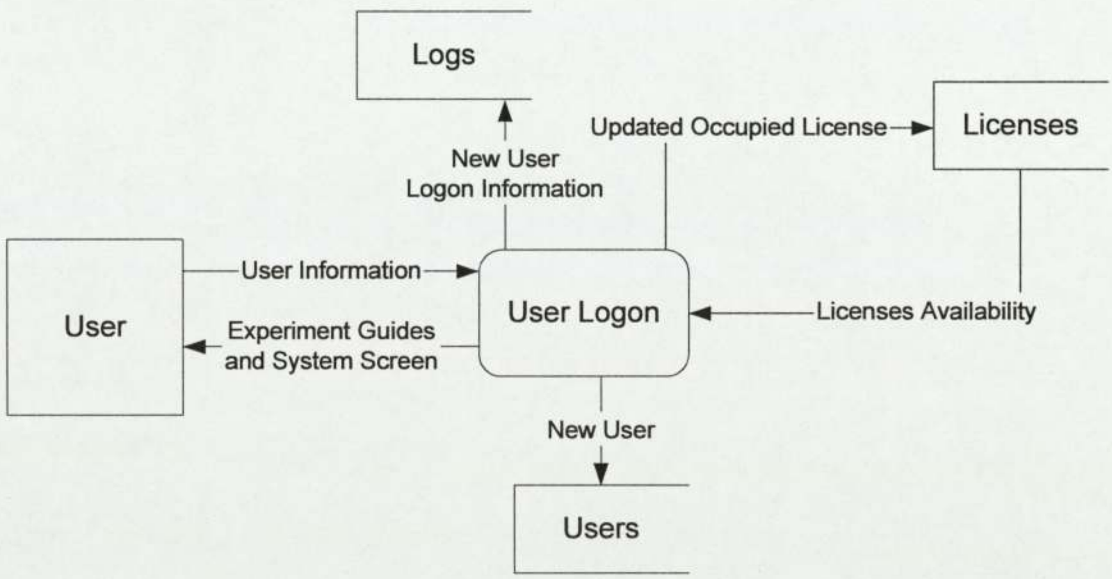

Figure 26. The event data flow diagram for user logon

laboratory prototype manages the experiment guide, the assessment tools, the system log, and provides other facilitating services for the experiments in the background.

During the experiments, the user can take assessments to check the learning performance anytime. The assessment handling process is depicted in Figure 27. The virtual laboratory prototype fetches the assessment question from the assessment questions data store, and then displays the question to the user. When the user sends the answer, the prototype compares the user's answer with the correct answer from the assessment questions data store. The assessment feedback is transmitted to the user immediately. The assessment results are also recorded in the assessment results data store and the logs data store, so the instructors and the laboratory administrator can examine them to understand the students' learning performance from the experiments.

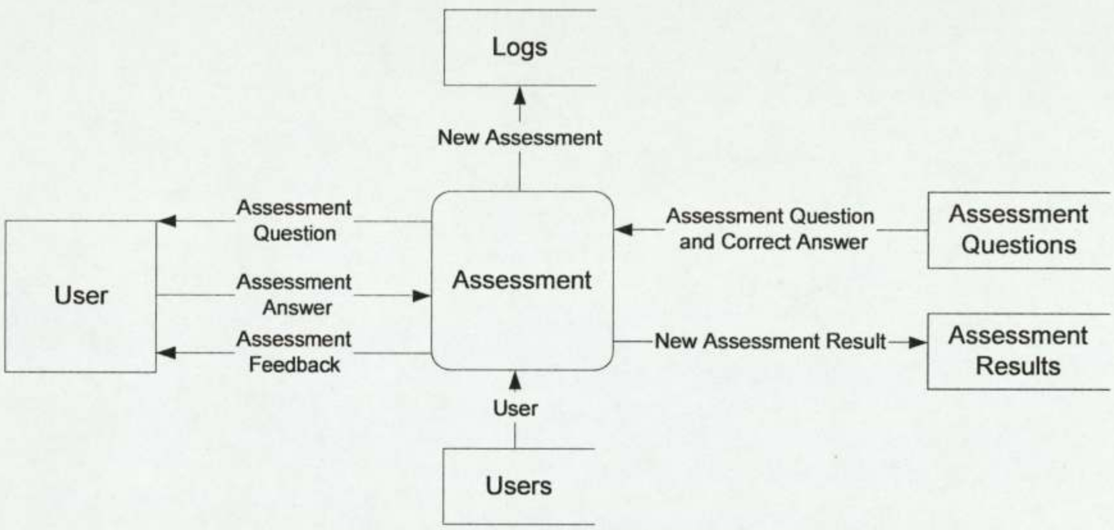

Figure 27. The event data flow diagram of assessment

When the user finishes the experiment, the user leaves the virtual laboratory prototype. The user logout event is designed to handle this process. This procedure first closes the Caliach Vision programme, and then restores the data file for Caliach Vision, and finally marks the occupied license as a vacated license. The user status in the user data store is updated. The logout information is also recorded in the logs data store. Finally the user receives the logout confirmation. The event data flow diagram of this event is depicted in Figure 28.

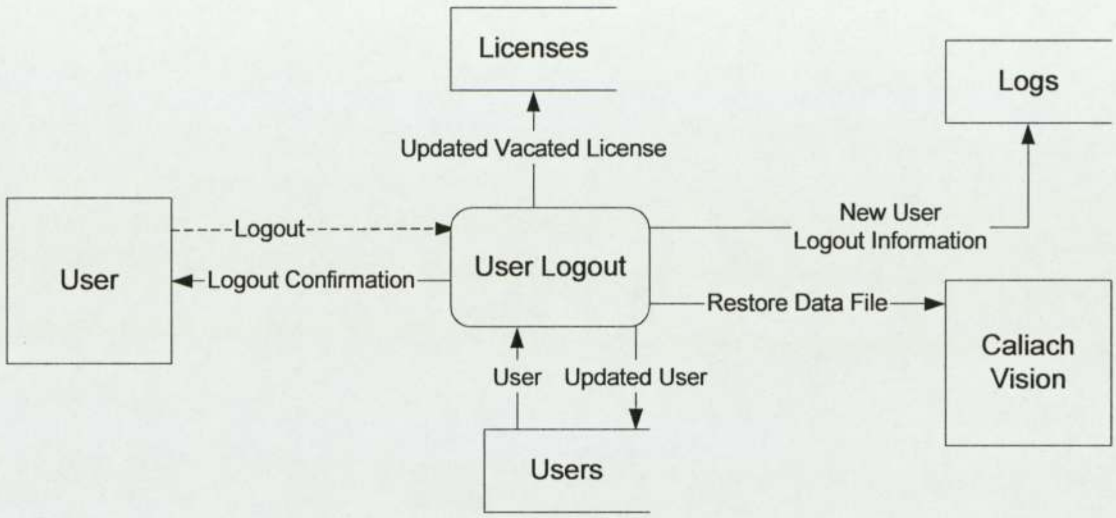

Figure 28. The event data flow diagram of user logout

The above three events are the user's main activities in the virtual laboratory prototype. However, there are some unexpected situations which might happen during the experiment. The most possible problem is that the user is disconnected from the prototype. This might be caused by a network problem, or errors on the user's computer or on the server, or by false operations of the user. There are two kinds of disconnection. In the first kind of disconnection, the virtual laboratory receives the disconnect order from the user's computer without the user's logout order. It happens when the user's browser is closed because of errors. This kind of event is defined as the user disconnect event. Another disconnection is defined as system disconnect. It triggers when the server does not get any responses from the user's computer for a long time. This might happen when there are errors on the network so the computers cannot communicate to each other or due to a sudden shut down of the user's computer. The handling methods for these two connections are depicted in Figure 29 and Figure 30. The handling processes for these two events are similar. The virtual laboratory first logs the disconnect information and updates the user status according to the different situation. However, the license will not vacate and the user's data file for Caliach Vision will still be kept on the server. This provides a chance for the user to reconnect to the virtual laboratory to pick up the using license and data file and continue the experiment.

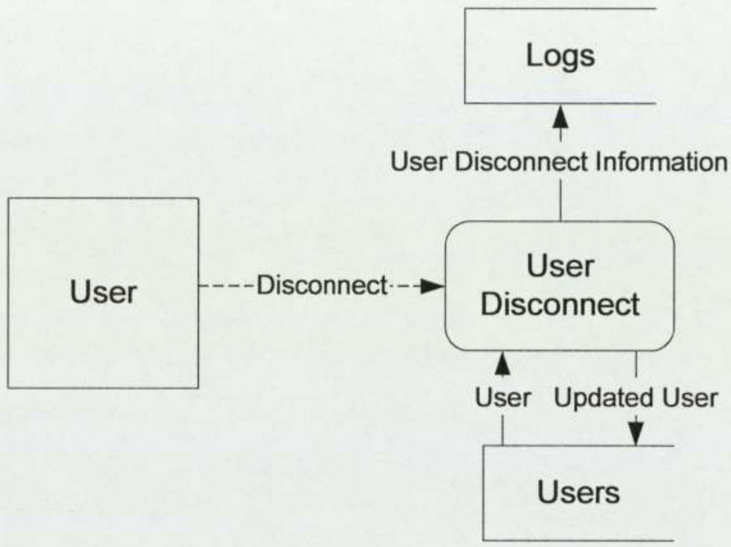

Figure 29. The event data flow diagram for user disconnect

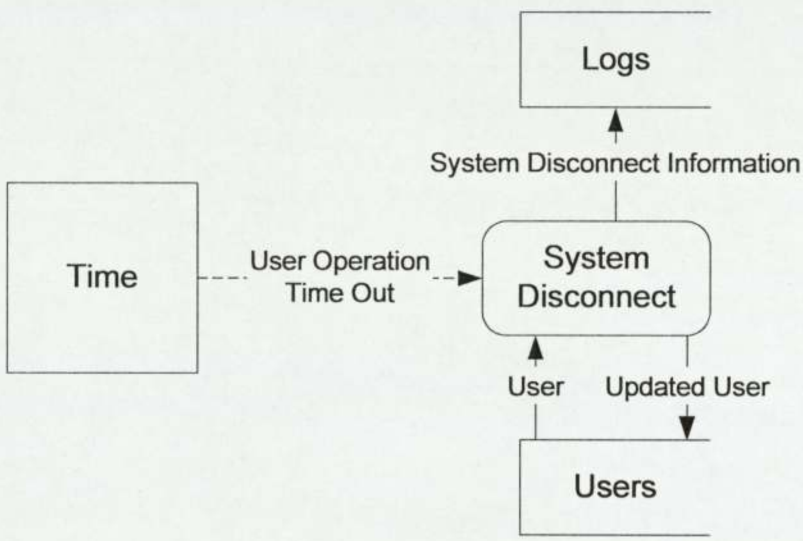

Figure 30. The event data flow diagram for system disconnect

The logical design describes the main data and processes for the virtual laboratory prototype. It focuses on what data and processes should be involved in the prototype and how they can be handled. But the logical design does not consider how to use the techniques to develop the prototype. The physical design, which will be discussed in the following paragraphs, focuses on how to use different techniques to design the prototype. The physical design for the prototype mainly utilises the techniques which are commonly used in the browser-server system development.

The physical design for the virtual laboratory prototype begins with the system architecture design.

The system architecture of the virtual laboratory is depicted in Figure 31. The user utilises the browser to connect to the virtual laboratory webpage through the Internet. Because the virtual laboratory needs to use ActiveX technology control to connect to the Terminal Service server, Internet Explorer is the recommended browser to access the virtual laboratory prototype. In terms of the server operation system, because of the technology requirement of Terminal Service, Windows server system is the only choice. It will be an ideal choice to separate the Web server (IIS server) and the Terminal Service server so that they can provide better performance. However, these two services can also be run on the same server.

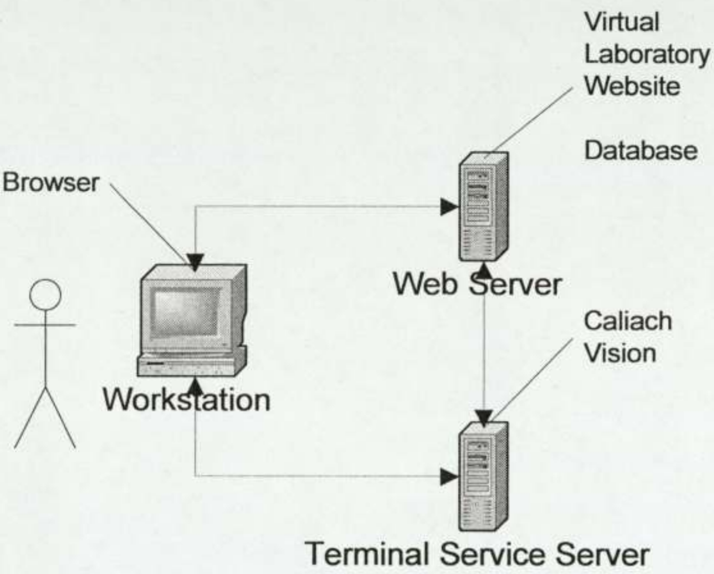

Figure 31. The system architecture of virtual laboratory

The virtual laboratory webpage is developed by HTML, ASP, JavaScript, and VBScript. The experiment guides are written in HTML so that they can be easily integrated into the prototype webpage. The data is stored in a simple Microsoft Access database. Caliach Vision is installed in the server which provides the Terminal Service.

Because providing the Terminal Service on the server makes it more at risk of unauthorised access, the security setting of the server needs to be enhanced. The security settings include limiting the user number of the server, limiting the Terminal Service user to use Caliach Vision only, stopping unnecessary services on the server, and applying a strict security policy. These security settings can protect the server to provide a feasible and stable service for the virtual laboratory.

The different technologies are collaborating in the virtual laboratory prototype to provide the service for the users. When the user enters the virtual laboratory prototype, the user is required to logon the prototype. And then the experiment webpages are shown to the user. The experiment guide and the Terminal Service Advanced Client are displayed on the webpage, while the other functions run in the background. The Terminal Service Advanced Client automatically connects to the Terminal Service server. The user only needs to input the username and password for the Terminal Service server, and then he or she can logon the server and the Caliach Vision programme starts automatically. Because the experiment guide and the assessment tools are provided by the Web server while Caliach Vision is run on the Terminal Service server, the Web server and the Terminal Service server are also collaborating. When the user finishes the experiment and logs out the virtual laboratory prototype, the Web server restores the data files of Caliach Vision. During the experiment, the prototype monitors the user's activities and records it in the logs, and the other data is also read or written to the data store by the prototype whenever necessary.

The user interface design of the virtual laboratory prototype is the other important part of the physical design. The user interface should be friendly enough for every new user, so that the user can get used to the user interface in a short period of time. The user interfaces are a series of webpages, because the virtual laboratory prototype is a Web-based programme. Apart from the experiment webpage, the other webpages are very simple. They only guide the user to go through the different processes, especially the logon and logout process, so they just use some notes to guide the user's operation. The experiment webpage is shown when the user is conducting the experiments in the virtual laboratory prototype. Its interface design is depicted in Figure 32.

This user interface design is composed of three areas. The top left area is the area displaying the experiment guide or the Caliach Vision screen. The experiment guide includes some screen cuts which provide examples for the user's operation, so it needs a large screen area. The Caliach Vision screen is displayed by the ActiveX control – Terminal Service Advanced Client. The user interface of Caliach Vision is displayed in this area, so the Caliach Vision screen area also requires a large screen area. The experiment guide and the Caliach Vision screen are put into different layers of the webpage. When one of them is shown, the other will be hidden. The user can select to show the experiment guide or the

Caliach Vision screen by pressing the control button on the bottom right of the webpage.

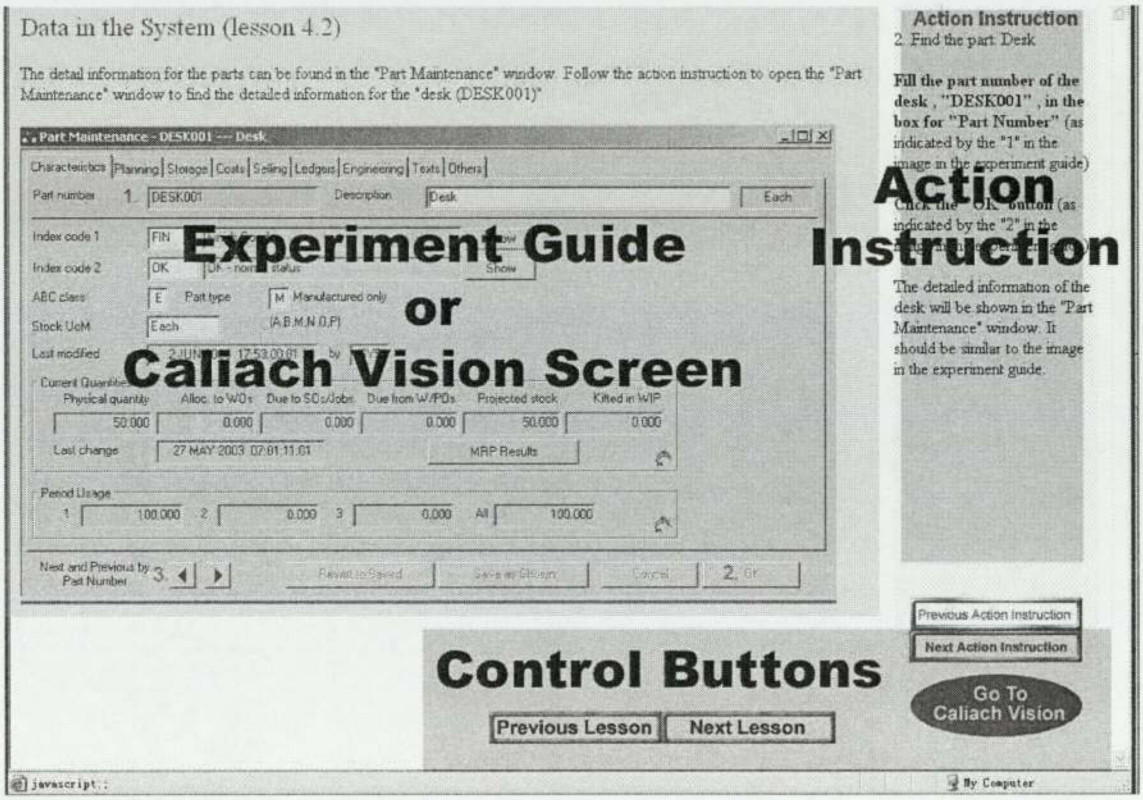

Figure 32. The user interface design of the virtual laboratory prototype

The top right area of the webpage is the action instructions area. Actually, the action instructions are part of the experiment guide. They lead the user to conduct the experiments in Caliach Vision step by step, and should be always on top of the user interface throughout the whole experiment. Therefore, the action instructions are separated from the experiment guide and displayed in the action instructions area.

On the bottom of the webpage is the control button area. The elliptic button in the bottom right corner can switch the display of the experiment guide or the Caliach Vision screen. The other buttons are used to navigate the different pages of the experiment guide and the action instructions.

In this section, the design of the virtual laboratory prototype is described. Based on the design, the virtual laboratory prototype is implemented in a real user involved environment and evaluated by the real users. The implementation and evaluation of the virtual laboratory is discussed in the next section.

6.1.3 The implementation and evaluation of the prototype

The virtual laboratory prototype is developed by the RAD and prototyping approach. When different users are invited to participate in the development, different functions of the prototype are implemented and evaluated, and different implementation environments and evaluation techniques are employed for the implementation and evaluation.

In the first prototyping rounds, the prototype was installed in the development computer and evaluated by the author and invited users. In this round, the main objective was to explore the possible techniques for the prototype and to test how these techniques could collaborate with each other.

In the second prototyping round, the prototype was installed on the server in the computer laboratory in Aston Business School, and the VLE administrator participated in the evaluation. The virtual laboratory prototype shared a server with another system, and the Terminal Service and Caliach Vision were also installed in the same server. Because the server's workload was not heavy, the performance of the virtual laboratory prototype would not be affected. The evaluation was mainly of the administration functions of the virtual laboratory prototype and the security settings of the server. The VLE administrator showed her satisfaction with the prototype.

The course instructor participated in the evaluation in the third prototyping round. The main issues in this round were the user interface design and the experiment guide design. Several versions of the user interface design had been evaluated. The final version is described in the previous section. Developing the experiment guide was also a challenging job. The experiment guide can significantly influence the user's effectiveness and efficiency in the experiments and affect their satisfaction towards the virtual laboratory prototype. The final experiment guide was comprehensive enough to describe every step of the experiment in detail, and explain the reasons and results of the step.

In the final prototyping round, the virtual laboratory prototype was implemented and evaluated by the students. Three classes of graduate students from Leicester University and Aston Business School were invited to attend the prototype evaluation. The virtual laboratory prototype still used the same server. But the students used different platforms to access the virtual laboratory prototype.

Some errors were encountered during the evaluation. On the third day of the student evaluation, an error occurred on the server's database connection. The database connection of the prototype became unstable after the server administrator changed some settings of the server. This error prevented the prototype from recording the user's activity and managing the licenses, so some users could not logon the virtual laboratory. Because this error happened at the weekend, the server administrator was not available to correct the error. The author had to change the database usage of the prototype so that the students could continue using the prototype. However, the prototype's log function was disabled and the other data also became incomplete because of the error.

Another error was that some students in Leicester University could not install the Terminal Service Advanced Client on their browsers, so they could not see the Caliach Vision screen in the virtual laboratory prototype. The author tried all the platforms in the computer laboratories of Aston Business School but could not reproduce the error they encountered. These errors indicate that the compatibility of the prototype still needs to be improved. The author conducted some improvement development during and after the evaluation. However, there was no more chance to invite the students to evaluate the improved prototype.

Despite the errors, the evaluation results confirm the successfulness of the prototype. About 50 students participated in the prototype evaluation. Because of the error on the database connection, the log data for the virtual laboratory was incomplete. Fortunately, the Web service log on the server could still provide some usage information. The Web service log cannot directly indicate how long they have stayed in the virtual laboratory and whether or not they conduct the experiment successfully. However, the log showed that at least ten users finished reading the experiment guide, and conducted the assessment successfully in the prototype, and there were also some other users who had read the whole experiment guide but did not conduct the assessment. Therefore the Web service log can prove that the virtual laboratory prototype is able to provide the experiment guide and assessments as designed for the students.

When the students were invited to evaluate the virtual laboratory, electronic questionnaires for the prototype evaluation were also sent to them. Unfortunately, only 4 users responded to the questionnaires. The response number is too low to represent the students' opinions towards the virtual laboratory prototype. However, all the respondents considered that the virtual laboratory was useful for learning (2 for very useful and 2 for fairly useful), and they hope to try some other applications in the virtual laboratory prototype in the future. One user addressed his comments as follows, "Talking for hours and having the best presenter in the world cannot achieve the hands on experience of this type of simulation. I think this type of practical demonstration is mandatory for e-Business teaching (and e-Marketing) and understanding." These responses confirmed the requirement of the virtual laboratory prototype and indicate that the prototype meets the requirements.

During the evaluation, the author used E-mail to provide technical support for some students. Apart from the fact that some students could not conduct the experiments successfully because they could not install the Terminal Service Advanced Client, others replied that they could finally conduct the experiments in the virtual laboratory prototype. These replies also confirm the effectiveness of the virtual laboratory prototype.

Overall, though some errors happened in the virtual laboratory prototype evaluation, the evaluation still proved that the virtual laboratory prototype is able to support the students to conduct the experiments through the Internet. The virtual laboratory prototype overcomes the time and space limitations of the campus computer laboratory successfully. However, the virtual laboratory prototype still requires improvement for different user environments and different experiment software systems.

6.2 The virtual laboratory of the VLE for IS graduate education

6.2.1 Revising the virtual laboratory prototype

From the requirement identification of the VLE for IS graduate education, the virtual laboratory was found as the missing function. The virtual laboratory function of the VLE for IS graduate education should support different IS experiments. The virtual laboratory prototype is designed to support the experiments for Caliach Vision in Aston Business School, so the design is limited by the specific environment. The virtual laboratory prototype requires improvement to meet the requirements of the VLE for IS graduate education.

As discussed in Chapter 5, there are two methods to support the experiments in the virtual laboratory. The first method is to facilitate the user to use the software installed on the server, the second method is to use simulation programmes. The virtual laboratory of the VLE for IS graduate education should support both methods so that it can support different experiments. It also needs to support the students to develop their projects.

The virtual laboratory prototype supports the students to experience Caliach Vision by connecting to the server and using the software installed on the server. The prototype supports the experiment by the first method discussed above. However, this design can only support Windows-based software experiments.

Some software experiments use the Web-based software but not the Windows-based software. The virtual laboratory prototype should be revised to support these experiments. The screen of the Web-based software can replace the Caliach Vision screen by only modifying the Web framework setting of the virtual laboratory prototype. Therefore, the users can access the webpages of the software in the virtual laboratory and the other functions of the virtual laboratory prototype can still work in this situation.

The virtual laboratory prototype should also be revised to support the experiments using the simulation programmes. The simulation programmes are designed differently according to different experiments. However, the virtual laboratory should be designed to suit every different simulation programme. The simulation programmes can be Web-based or Windows-based, but they still run in the same way as the normal software. Therefore the virtual laboratory can support the simulation experiments in the same way as supporting the Windows-based or Web-based software experiment. The design of the virtual laboratory prototype does require more changes to suit this situation.

The students also need to use the virtual laboratory to develop their projects. In such a situation, the virtual laboratory just needs to help the students to use the computer with the development applications, while the experiment guide and action instructions function are not necessary. To suit this situation, the virtual laboratory prototype should remove the experiment guide and the action instructions, extend the screen area for the Terminal Service Advanced Client and remove the assessment function, but the user activity log, license control, data file control and security control functions should still be kept.

In summary, the virtual laboratory prototype needs to replace the ActiveX control to support the experiments on the Web-based software, or to modify the user interface design and remove some functions to support the project development. The data and the functions of the virtual laboratory prototype do not need major revising to meet the requirements of the virtual laboratory of the VLE for IS graduate education.

However, the logon process of the virtual laboratory prototype needs to be changed to allow the users to select the experiments. It would be better that every experiment has its own specially designed experiment webpage in the virtual laboratory. The new event design for the user logon event is depicted in Figure 33. The other parts of the virtual laboratory prototype do not need to have major changes, and the design models are not changed.

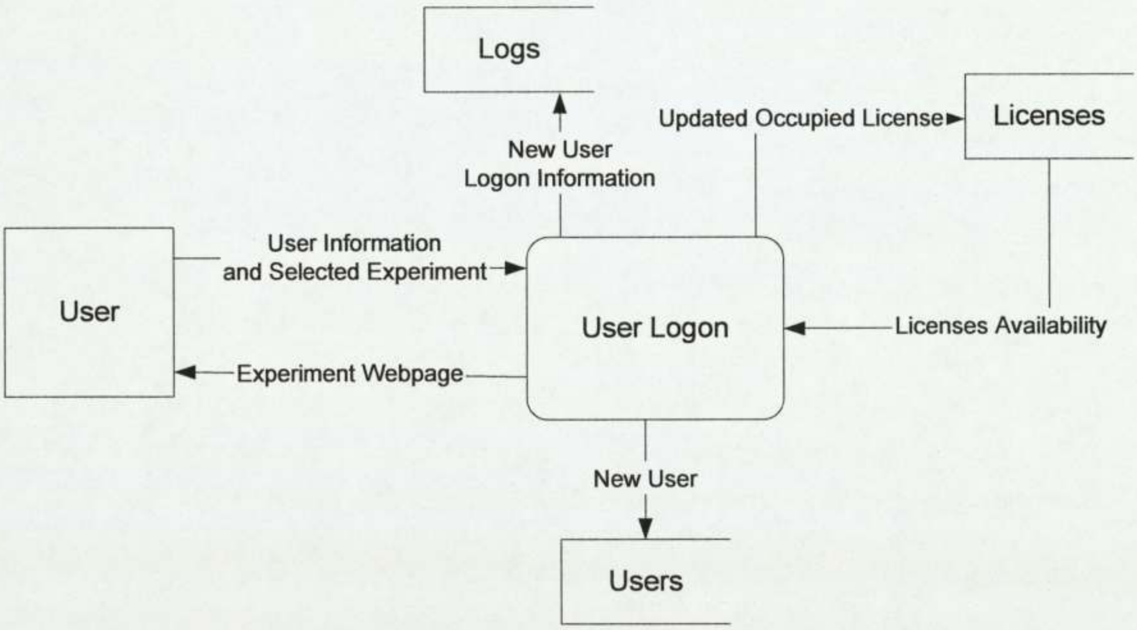

Figure 33. The changed event data flow diagram for user logon

6.2.2 Integrating the virtual laboratory into the VLE for IS graduate education

The current VLEs can already provide a variety of functions. However, as discussed in Chapter 5, the virtual laboratory function is missing in the current VLEs, which means they cannot fully support IS graduate education. A virtual laboratory function has been designed in the research project. How to integrate the virtual laboratory into the VLE will be discussed in this section. After the integration, the VLE can provide the required functions for IS graduate education, though some minor improvements might still be needed.

As discussed in Chapter 2, many VLEs provide interfaces to integrate with other applications. The feature is utilised in the integration of the virtual laboratory and the VLE. However, different VLEs have different technical requirements on utilising the interfaces. To simplify the discussion, Blackboard is utilised as the sample VLE in the integration. The integration includes two parts: integration of data and integration of user interface.

The integration of data begins with identifying what data can be integrated. The technical references (Blackboard.com, 2003) of Blackboard are reviewed to find what data can be provided and what can be accepted by the VLE. The virtual laboratory's user data and the assessment results data can use the data existing in Blackboard. The virtual laboratory can read the users data from Blackboard. The virtual laboratory can also submit the user assessment result to the grade book data of the Blackboard. Therefore, the data management and grade book management functions in the Blackboard can be utilised to maintain the user and assessment results data of the virtual laboratory. However, the other data of the virtual laboratory cannot be integrated into Blackboard because Blackboard does not have the corresponding data. These data are still managed by the virtual laboratory. After the data integration, the context data flow diagram for the virtual laboratory is changed into Figure 34.

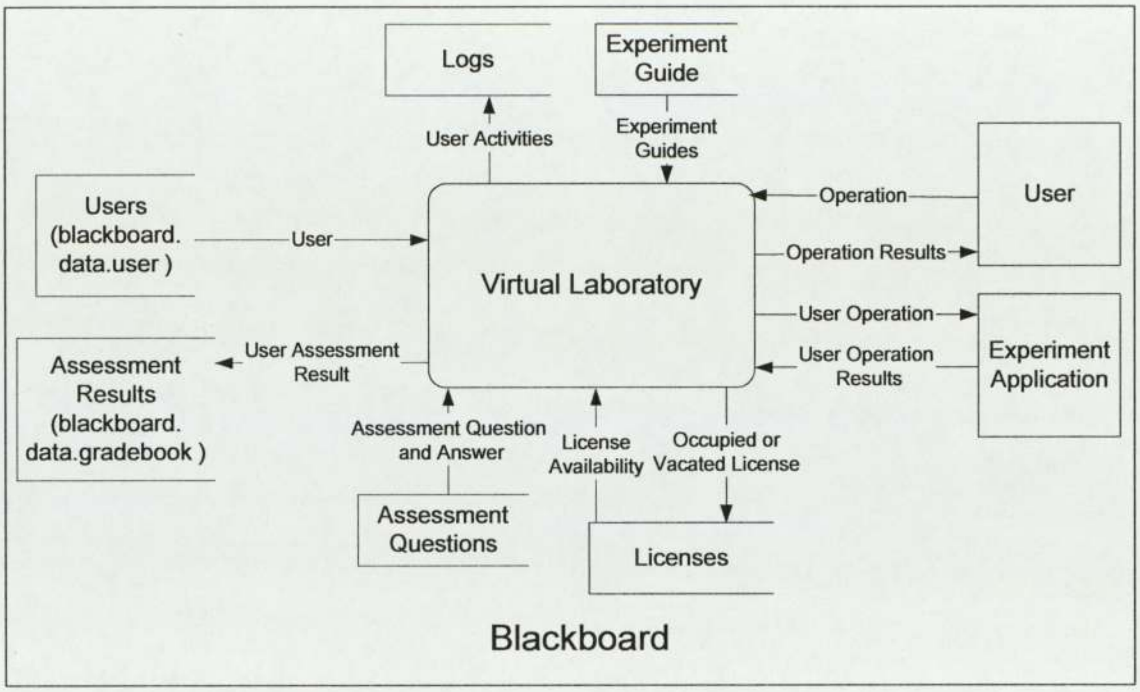

Figure 34. Context data flow diagram for the integrated virtual laboratory

After the data integration, the user is required to logon Blackboard before he can access the virtual laboratory, and the virtual laboratory can also confirm the user's role from Blackboard. Therefore, the virtual laboratory is more secure. Moreover, the student's experiment performance can be reported and the student's experiment activities can be analysed by Blackboard. This is helpful for the instructors.

Integrating the user interface of the virtual laboratory into the VLE is relatively simple. Because both Blackboard and the virtual laboratory prototype are Web-based, the user interface can be easily integrated by redesigning the webpage of the virtual laboratory prototype to suit the style of Blackboard.

The above integration employs Blackboard as an example VLE. The integration process of the other VLE is similar with this integration. After the integration, the integrated VLE is able to provide the virtual laboratory function for the users. Supported by a broad range of functions, the integrated VLE would be a suitable VLE for IS graduate education.

6.3 Summary of the virtual laboratory development

A variety of functions are provided by the current VLEs. However, one function required by IS graduate education is missing in the VLEs. This function is the virtual laboratory. A virtual laboratory has been developed in this chapter to supplement the VLE for IS graduate education.

A virtual laboratory prototype is developed by the RAD and prototyping approach. This prototype employs Terminal Service to allow the users to use the software installed on the remote server. A variety of functions are also designed to facilitate the experiment process. Though some still exist, the prototype is proved to be able to support the Caliach Vision experiment in Aston Business School.

After the investigation of IS graduate education, the requirements of the VLE for IS graduate education have been identified. The virtual laboratory function is the major missing function of the VLE for IS graduate education. The virtual laboratory prototype is revised to meet the requirements of the VLE, and then it is integrated into the current VLE to complete the VLE for IS graduate education.

CHAPTER 7 CONCLUSION AND RECOMMENDATIONS

7.1 The key findings

Developments in IT have led to a rapid expansion of IS education. Both the depth and the breadth of IS education have been greatly extended during the last four decades. The rapid development in IS education has made teaching and learning of IS become challenging work for both instructors and students.

An investigation into the current situation of IS graduate education has been conducted by reviewing the webpages for IS programmes and courses in the top business schools in the Asia Pacific region, the UK, and the US. The investigation confirms the important role of IS in business education. Many MBA programmes also provide IS courses as required courses or elective courses. The e-business programme and course is found to be an important component of IS education.

The IS programmes in the top business schools tend to emphasise business issues or offer a balance between both technology and business issues. Few IS programmes which focus on technology have been found in the investigation of the business schools. Case studies, laboratory experiments, team projects, individual projects and industry speakers are the most frequently used teaching methods in IS education.

By comparing the situation of IS education in the Asia Pacific region, the UK and the US, the top business schools in the Asia Pacific area are found to be more likely to provide IS graduate programmes, whether an e-business programme or the normal IS programme. The MBA programmes in this area also provide more IS courses as required courses, while the MBA programmes in the UK provide fewer IS courses as elective courses.

The developments in IT also inspired the development of the VLE. VLEs can improve the flexibility of learning, provide student-centred learning style, share and reuse learning resources, support collaboration among students, and reduce the administrative burden for the instructor. The VLE is very valuable for IS education.

The VLE for IS graduate education should be able to reuse the learning resources and teaching methods of the traditional learning environment. The advantages of IT should also be employed in the VLE. A function model of the VLE for IS graduate education have been suggested based on the information provided by the literature review and the investigation into the situation of IS graduate education. Information from the literature review can imply most of the required functions. The investigation result confirms the requirements identified based on the literature review, and suggests the importance and more features of the virtual laboratory function. The current commercial VLEs have provided most of the functions needed by IS graduate education. However, the virtual laboratory function is missing in the VLEs.

A virtual laboratory prototype is developed in this research project by the RAD route. The prototype employs the Terminal Service technology to facilitate the users to use the software installed on the server and perform the experiment. A variety of functions, including assessment, license control, data file control, and security control functions, are embedded into the prototype. Passing through the evaluation, this prototype proved to be able to support the experiment on Caliach Vision in Aston Business School, though some limitations exist.

The virtual laboratory prototype is revised to suit the requirements of the VLE for IS graduate education. How to integrate the virtual laboratory into the VLE is also discussed. This virtual laboratory function can supplement the VLE to fulfil the function model of the VLE for IS graduate education.

7.2 The limitations of the research and recommendations for further research

In the research project, the situation of IS graduate education is investigated and a virtual laboratory is developed to supplement the VLE for IS graduate education. However, some limitations also exist in the research.

This research project only utilizes the information on current teaching practise in IS graduate education. IS graduate education is developing rapidly and new teaching contents, teaching methods and technologies are emerging. Therefore the research result may be outdated in a short term. The further research should put more emphasis on the new development.

Because of the limitation of the scope of the MSc programme, reviewing the IS programmes and courses webpages was the most suitable research method to investigate the situation of IS graduate education. While some of the webpages can provide comprehensive information, some only provide incomplete information for the investigation. Conflicting information is also found on the webpages of some programmes and courses. Though the author tried to avoid the effects by conducting more detailed search on the related webpages and clarifying the most updated information, these limitations still affect the credibility of the research.

The investigation is conducted in a relatively limited sample range. The samples are from IS programmes and courses in the business schools in the selected geographic locations. These samples are representative samples of IS education so the most important features of IS graduate education should have been identified. However, a broader sample range will be helpful to get a more accurate research result of the situation of worldwide IS graduate education. More research using other research techniques will also be valuable to complement the research on the situation of IS education and the requirements of the VLE for IS graduate education.

The investigation into the situation of IS graduate education only confirms the functions identified from the literature review and suggests the importance and features of the virtual laboratory function. No new functions of the VLE can be identified from the investigation result.

The requirement identification of the VLE for IS graduate education is not very comprehensive. Only the functional requirements of the VLE are identified, but the detailed requirements for the functions are not identified yet. The requirement identification cannot confirm whether or not the detailed features of the current VLEs suit IS graduate education. Though a common model of the VLE has been suggested, the universities still need to identify the requirements in a more detailed level when they need to utilize the VLE for IS graduate education in their programmes and courses.

The virtual laboratory prototype designed in the research project can satisfy the requirements of the experiment, but it still has some limitations. The compatibility and stability of the prototype also need to be enhanced. The prototype design and evaluation are limited by the course setting and the student availability. The prototype will be evaluated in a IS graduate course in China in which the student are required to have experiments on Oracle E-Business Suit system. After this evaluation, the virtual laboratory prototype should be more compatible and stable.

The revising of the virtual laboratory prototype and the integration is not conducted at a detailed level. The revised virtual laboratory and the integrated VLE are not implemented and evaluated by the real users, so practicability and credibility cannot be confirmed.

Overall, to develop a VLE specially designed for IS graduate education is a complicated task. This research project is just the first step to explore the requirements and supplement the most important missing function. More effort is still needed to be put into this area in order to improve the VLE for IS graduate education.

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APPENDIX A. LIST OF THE INVESTIGATED UNIVERSITIES

University Name	Location	Location Group
Curtin University of Technology	Australia	Asia Pacific
Macquarie University	Australia	Asia Pacific
University of Melbourne	Australia	Asia Pacific
Mount Eliza Business School	Australia	Asia Pacific
Queensland University of Technology	Australia	Asia Pacific
RMIT University	Australia	Asia Pacific
University of Adelaide	Australia	Asia Pacific
University of Queensland	Australia	Asia Pacific
University of South Australia	Australia	Asia Pacific
University of Technology Sydney	Australia	Asia Pacific
Insead	Singapore	Asia Pacific
Chinese University of Hong Kong	Hong Kong	Asia Pacific
City University of Hong Kong[1]	Hong Kong	Asia Pacific
Open University of Hong Kong[1]	Hong Kong	Asia Pacific
University of Hong Kong	Hong Kong	Asia Pacific
Cheng-chi University	Taiwan	Asia Pacific
Taiwan University of Science & Technology	Taiwan	Asia Pacific
University of Aberdeen[2]	UK	UK
Aston University	UK	UK
University of Bath	UK	UK
University of Birmingham	UK	UK
City University	UK	UK
University of Durham	UK	UK
University of East Anglia	UK	UK
University of Exeter	UK	UK
University of Glasgow[2]	UK	UK
Imperial College London	UK	UK
Lancaster University	UK	UK
University of Leeds	UK	UK
Leeds Metropolitan University	UK	UK
The University of Liverpool	UK	UK
London Business School	UK	UK
The London School of Economics and Political Science	UK	UK
Loughborough University	UK	UK
The University of Manchester	UK	UK
The University of Nottingham	UK	UK
Nottingham Trent University	UK	UK
The University of Oxford	UK	UK
Oxford Brookes	UK	UK

Queen's University, Belfast	UK	UK
The University of Reading	UK	UK
Royal Holloway, University of London	UK	UK
University of Southampton	UK	UK
University of Strathclyde	UK	UK
University of Surrey	UK	UK
University of Ulster	UK	UK
University of Manchester Institute of Science and Technology	UK	UK
University of Warwick	UK	UK
Carnegie Mellon University	US	US
Columbia University	US	US
Cornell University	US	US
Dartmouth College	US	US
Duke University	US	US
Georgetown University	US	US
Harvard University	US	US
Indiana University	US	US
Massachusetts Institute of Technology	US	US
New York University	US	US
North Western University	US	US
The Ohio State University	US	US
Stanford University	US	US
University of North Carolina at Chapel Hill	US	US
University of California Berkeley	US	US
University of California Los Angeles	US	US
University of Chicago	US	US
University of Michigan	US	US
University of Pennsylvania	US	US
University of Southern California	US	US
University of Texas	US	US
University of Virginia	US	US
Yale University	US	US
University of Navarra	Spain	Other
IMD	Switzerland	Other

Notes:

1. City University of Hong Kong and Open University of Hong Kong do not provide full-time on campus IS programme or course, therefore no IS programme or course data are collected from these two universities.

2. University of Aberdeen and University of Glasgow do not have an IS programme or course in their business school, therefore no IS programme or course data are collected from these two universities.