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Originally published in the Proceedings of the EDU-COM 2008 International Conference. Sustainability in Higher Education: Directions for Change, Edith Cowan University, Perth Western Australia, 19-21 November 2008.
This Conference Proceeding is posted at Research Online.
http://ro.ecu.edu.au/ceducom/35

Economic Sustainability of Remote Access Networking Classrooms

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ABSTRACT

Within the higher education domain, there is a prevalent belief that e-learning, virtual classroom and tele-education are essential requirements for the long-term effectiveness and success of educational institutions. Many information technologies have been adopted to assist studying and learning remotely and are hence potentially beneficial to students, teachers and educational providers. For educational providers, the benefits are that there are no physical or geographical limits to the number of students that can be enrolled in a course of study. However, within the field of network technology, students must actually use network devices during their studies. This is important not only because it significantly enhances student learning, but also within this field, employers expect students to have practical 'hands-on' experience. Software simulators are available but they cannot provide students with the necessary practical experience of connecting together the physical devices. Despite the requirements to provide a 'hands-on' approach it effectively eliminates remote on-line students. Edith Cowan University (ECU) invested over AUD$350,000 in dedicated network teaching laboratories, which are considered to be of a 'world-class' standard. An access server has been used to provide remote students with access to this equipment. Significantly it is also possible to view the actual network devices by means of a webcam. Whilst remote access to equipment has been possible students only interact via a computer screen. This work allows students to interact by means of Webcam (visual) and Voice over Internet Protocol (VoIP) (audio). Work to date has consisted of establishing the appropriate infrastructure and testing the communication links. Further trials are planned for semester 2, 2008. Traditional remote access can only operate via Command Line Interface (CLI), this can be difficult for many students to practice and gain experience in computer network and internetworking. In effect on-line students will be able to conduct their workshops on a remotely located 'world class' network laboratory. For students, the on-line curriculum is available twenty four hours a day; there is typically on-line support, and software is now available allowing access to recorded lectures.

Keywords: Computer network education, Distance learning, Remote access classroom

INTRODUCTION

Information technology (IT) is employed in many organizations as a means to support environmental sustainability. The term of sustainability refers to the potential longevity of vital human ecological support systems, such as the planet's climatic system, systems of agriculture, industry, forestry, fisheries, and the other systems on which they belong (Tisdell, 1988). Many educational institutions are being forced to find better pedagogical methods to cope with these new challenges (Jonsson,

2001). Remote access for students can also assist sustainable development. Sustainable development, this refers to a pattern of resource use which focuses to meet human needs and preserving the global environment. According to the United Nations (1987), the grounds for sustainable development are divided into three elements (figure 1): environmental sustainability, economic sustainability and social sustainability.

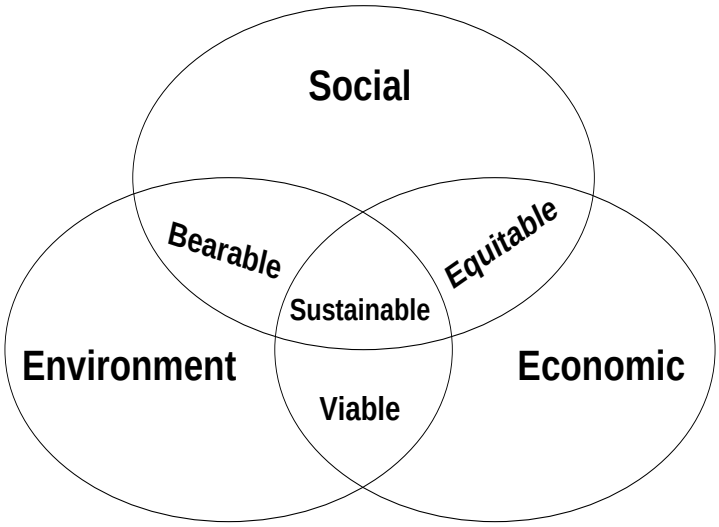

Figure 1: *Sustainable development (the United Nations, 1987)*

These elements have been used and applied in an educational environment which provides explicitly considering technology's possibilities to facilitate social interaction between teachers and students, or among students via technology (Vosniadou et al., 1996; United Nations, 1987). However, while performance, capabilities, demand, skills, practice and experience are significantly increasing, educational providers need to create a sustainable education for generating the best pedagogical models which support learning and teaching environments. In social sustainability, students from developing countries or joint universities can access from their own countries to use the equipment; meanwhile, in terms of economic sustainability; foreign universities do not need to purchase or maintain expensive networking equipment.

Combining the objectives of remote access networking classroom and sustainable development diagram; therefore, the results of the dimensions of sustainability are shown in table1.

Table 1: *The dimensions of sustainability of remote access networking classroom*

	Environment	**Social**	**Economic**
Bearable	- Overseas' students will have a better understanding of computer networks in their own countries	- Creates social long-term learning without being limited to time and place	- For remote students, no need to travel; therefore, this can save some money for travelling, accommodation, petrol, etc.
Sustainable	- No need to travel so students will have plenty of time for practice and gaining skills and experience	- Students can configure the network equipment through remote access laboratory - Allow students to collaborate among	- For collaborative universities, they do not require to buy the equipment - For ECU who provides the equipment; the

		students which lead to be a new social learning group.	university will gain some extra revenue and some intangible benefits
Equitable	- With same lecture note materials and workshops, remote students make them feel to have an equitable to access and gain knowledge as same as local students	- All of equipment can be shared when they are available	- Overseas students have ability to practice with the equipment as the same as another student at ECU
Viable	- Study computer network can be done from anywhere	- Allow students to practice with real workshop in the same material as local students, so they can have an opportunity to discuss the problems and help each other to find out the alternative solutions	- As ECU has invested in physical equipment; those equipment can provide a lot of benefits such as using for research, using for teaching, using for experiment and using for training special course

This paper presents an example of a sustainable remote access networking classroom which can be used as a technological framework for integrating an experimental-based internetworking environment or the other online curriculum for universities. The authors have designed and facilitated a remote internetworking experiment via two communication links; Edith Cowan University (ECU) in Australia - Kobe University in Japan, and ECU – Nakorn Phanom University in Thailand. The main objective of this experiment was to provide networking equipment for both on-campus and off-campus students who live in remote areas or via collaboration with other universities. A remote access networking classroom was designed by focusing upon improving early learning outcomes, fault diagnosis, changing configurations on network equipment and upon other aspects of sustainable technologies. By using a visual (webcam) combined with audio (VoIP) technology, this enabled the possibility of a rich student learning experience.

The objectives of this experiment included:

1. to develop further a student's understanding of computer networks and data communication principles;
2. to develop a student's ability in designing, configuration and monitoring of computer networks;
3. to provide students knowledge of how internetworking protocols are implemented into the networks, network operating systems (NOS) and dedicated embedded hardware;
4. to enhance student understanding of the current standards and future direction in computer networks and data communications;
5. to develop student's ability in analyzing computer network problems and maintaining a network's status.

All of these objectives were included in the experimental remote access networking classrooms.

In this paper, the authors focused upon economic factors in sustainable education in more details than social and environmental influences.

ECONOMIC BENEFIT

In this section, the authors focus upon the remote access experimental classroom by analyzing time management and Cost-Effectiveness Analysis (CEA)

A) Time Management

The School of Computer and Information Science (SCIS) at ECU has two main internetworking laboratories for teaching and learning in computer networks. Fully internetworking equipment, network operating systems, and network applications are provided such as routers, switches, firewalls, hubs and wireless access points (figure 2). Obviously, using internetworking equipment assists students to develop their understanding and improve their networking skills. For semester 1-2008, these laboratories had been utilized five days a week:

Monday	: 12:30 pm – 16:30 pm for Fundamentals of Computer and Network Technology (4 hours)
Tuesday	: 10:30 am – 12:30 pm and 14:30 pm – 16:30 pm for Remote Access (4 hours)
Wednesday	: 09:30 am – 17:30 pm for project and research students (8 hours)
	: 17:30 pm – 21:30 pm for Internetworking 1 (4 hours)
Thursday	: 08:30 am – 12:30 pm for Internetworking 1 (4 hours)
	: 12:30 pm – 16:30 pm for Internet Technology and Management (4 hours)
	: 17:30 pm – 21:30 pm for Internetworking 2 (4 hours)
Friday	: 08:30 am – 12:30 pm for Internetworking 2 (4 hours)
Estimate time	: for maintenance, lecturer and tutor time to test (4 hours)

Thus, the totally percentage of the use internetworking laboratories at ECU was 33.33 while 66.67 was available. This percentage refers that both two laboratories have available for remote students and overseas students.

Figure 2: *Equipment racks in the computer networking laboratory at ECU*

B) Cost-Effectiveness Analysis

In order to investigate sustainable remote access classroom, cost-effective analysis (CEA) is the method has been used. CEA is a financial form of economic analysis in which all expenditure or costs

are related to common effects and outcomes (National Business Group, 2008). CEA can identify the alternative financial outputs, minimizes the actual value of costs, and is a tool for the selection of alternative projects with the same objectives (quantified in physical terms). Three internetworking laboratories have been evaluated (Table 2, 3).

Table 2: *An Investment cost for three internetworking laboratories*

Internetworking Laboratories	**Investment cost (AUD)**	**Annual fixed (Maintenance costs) 10% of investment cost**	**Annual reserve costs 5% of investment cost**	**Total investment cost**
Edith Cowan University (ECU)	500,000	50,000	25,000	**575,000**
*** Kobe University (KU)**	300,000	30,000	15,000	**345,000**
Nakorn Phanom University (NPU)	100,000	10,000	5,000	**115,000**

* The investment cost in internetworking laboratory at KU in Japan has been estimated 50% of investment cost between ECU and NPU

A tuition fee is the primary tangible benefit that we used for analyzing cost-effectiveness. At ECU, for two semesters, the number of postgraduate students who have enrolled internetworking units should be 150 (5 units * 30 students) and estimate that most students are international students; hence, according to ECU International, the fixed tuition fee per head per semester for international student is 8,000 AUD (ECU International, 2008).

At KU, in 2008, the number of postgraduate students who have enrolled in faculty of engineering, major computer science and systems engineering should be 85 (5 units * 17 students) and estimate that most students are local students; hence, according to KU prospective students, the fixed tuition fee for both international and local student per head per year is 535,800 YEN (Kobe University, 2008). (1 AUD: 101 YEN: 3 July 2008; Currency.com, 2008)

NPU, in 2008, had no postgraduate students in the faculty of computer science, faculty of information technology and faculty of engineering, as NPU is a new government university and was established in 2005 by combining the local existing institutions. For two semesters in undergraduate program, this university has run only one internetworking unit per year; thus, the number of undergraduate students who have enrolled internetworking units should be 30 (1 unit * 30 students) and estimate that almost students are local students. For the government university, the estimated tuition fee per head per semester is about 8,500 BAHT in faculty of science (Nakorn Phanom University, 2008). (1 AUD: 32 BAHT: 3 July 2008; Currency.com, 2008)

Table 3: *Benefits from each university*

Internetworking Laboratories	**Tuition fees (AUD)**
Edith Cowan University (ECU)	**2,400,000** (16,000 AUD * 150 students)
Kobe University (KU)	**450,921** ((535,800 JPY/101)*85 students)
Nakorn Phanom University (NPU)	**7,969** ((8,500 THB/32)* 30 students)

For **Cost-Effectiveness Ratio =** $\frac{\sum \textbf{Benefits}}{\sum \textbf{Costs}}$

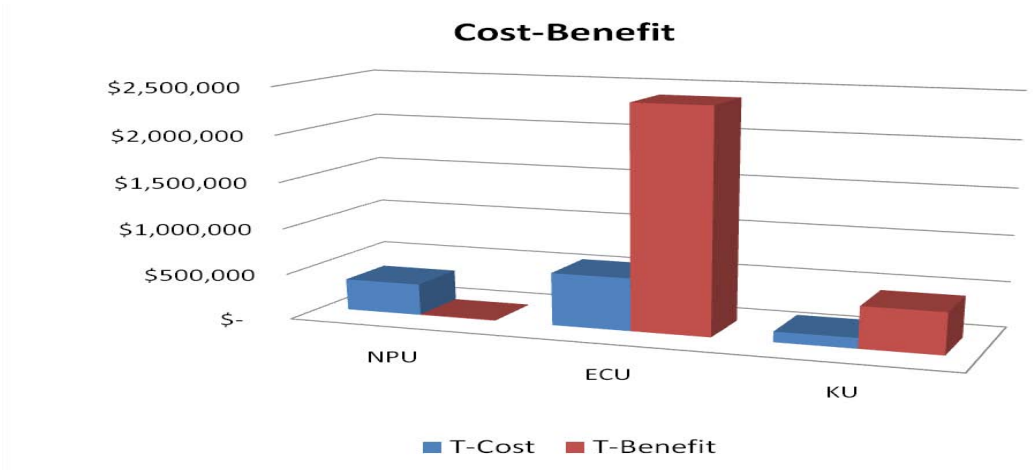

Figure 3: *The comparison of investment cost and benefit at NPU, ECU and KU*

It can be clearly seen on figure 3, the comparison of investment cost of each university in networking laboratory and tangible benefit. Comparing with NPU and KU, ECU has gained a huge benefit from its investment as seen in figure 4.

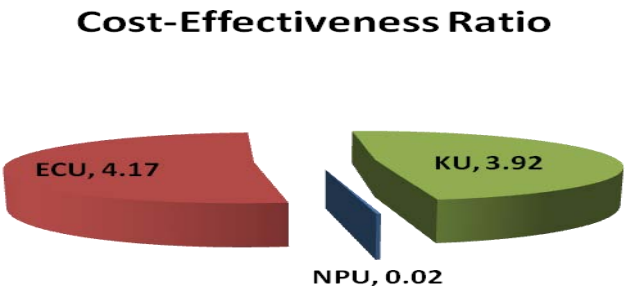

Figure 4: *Cost-Effectiveness Ratio*

THE REMOTE ACCESS NETWORKING CLASSROOM

In the networking laboratory, remote students can access network equipment via the website (Web Conferencing Services) and then connect through an access server which is password protected. In order to configure the network equipment at ECU, the use of the CLI, Webcam and Voice over Internet Protocol (VoIP) are used in the laboratory in this experiment. The CLI is used to configure the equipment whilst the webcam and VoIP are used for communication between students and lecturers to identify the problems and to assist when required. Remote students can choose which network topologies and technologies they wish to practise. In this experiment, network topologies, workshop instructions, and lecture notes are provided. Figure 5 shows the connectivity by using remote access to configure networking equipment.

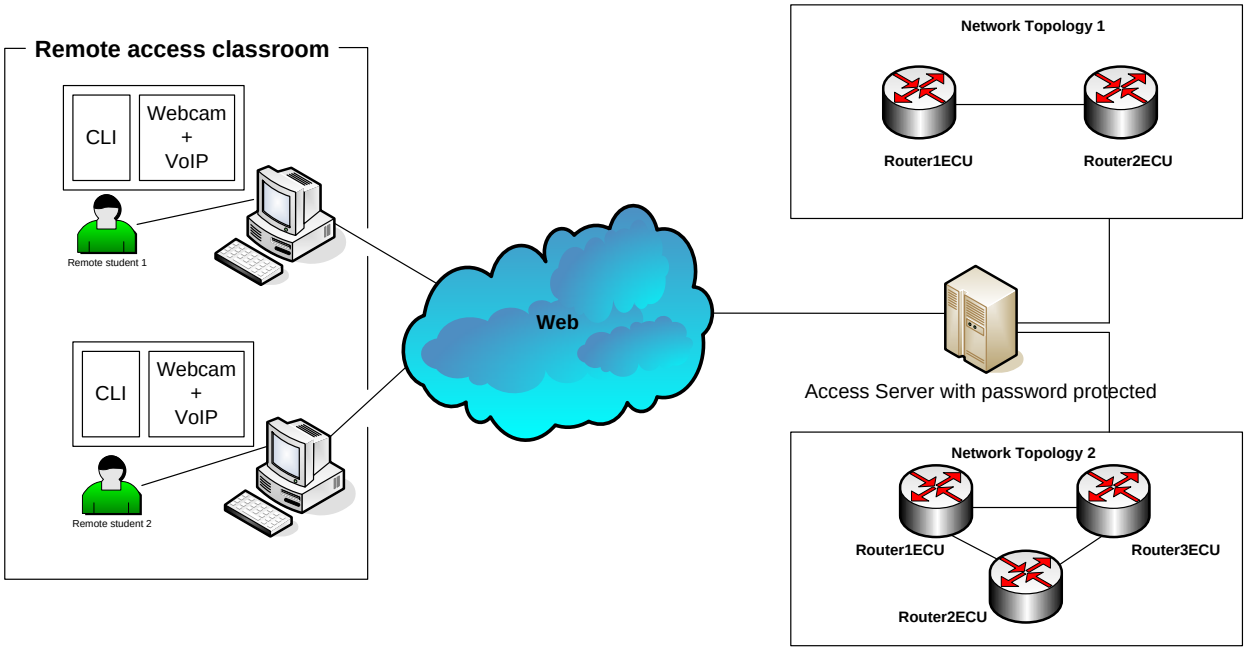

Figure 5: *The connectivity of the remote access classroom*

After providing workshops, network topologies and lecture notes, the physical networking equipment has been prepared and setup, the authors noted that all the connections and networking equipment seemed to be match with the network topologies and workshop instructions. By observation in this experiment, the authors noted that it was successful in enhancing the learning of the remote students. However, some technical problems during the experiment need to be addressed.

A) The increasing role of using remote networking classroom

The remote access networking classroom at ECU, is a dedicated laboratory that has fully networking equipment for supporting teaching and learning. The experimental projects between ECU-KU and ECU-NPU have shown that the remote access networking classroom provides sustainable economic, environmental and social benefits in learning and teaching processes. According to Bransford et al. (2000), a conceptual framework is to represent facts and ideas while practicing with physical equipment assist learner in gaining superior knowledge, skills and experience.

In terms of economic, remote students do not need to travel; this can help students to save petrol, travel costs, time, and accommodation. According to Laitner (2003), the usage of IT from remote site could reduce the growth in carbon emissions by over 67 percent.

The remote access networking classrooms also bring many social benefits to both teachers and student life. For example, creating a new social long-term knowledge and learning by sharing skills, experience and resources. Some special collaborative projects from remote universities can be operated via remote access. To allows teachers and students to have flexible work and time to study. According to Massy and Zemsky (1995), to make learning more productive is to make it available and possible for students to get the resources that they need when they need them.

B) An awareness of remote classroom

There are some challenging issues which are of concern in remote access classrooms. Firstly, some remote students might learn better in a traditional classroom. They need the live interaction with an instructor and other students. Even through, a remote access networking classroom may try to simulate classroom interaction, they cannot duplicate it completely because it is virtual and not real. In order to succeed at using remote access networking classroom effectively, some remote students need to have

some specific skills in configuration and fault finding. They have to be self-motivated, responsible for their own learning and they should also have good time management skills. If they do not have those skills, traditional classes may be a better alternative.

In some developing countries the major challenge of using remote access is accessibility. Not everyone and every university have ready access to computers with an internet connectively. Without this provision, it is hard to make remote access networking classrooms a viable reality. The importance of the online environment is flexibility and portability for many teachers, students and staff and hence remote access classrooms may a good solution.

CONCLUSIONS

This paper has presented the sustainability remote access networking classroom which provides the potential for beneficial teaching and learning for many students, staff and universities especially in developing countries. A significant issue for sustainability remote access networking classroom is to provide not only low cost access to network equipment but also an improved pedagogical outcomes for remote students. Involving students in remote on-line university can potentially overcome the problem of the lack network equipment with which to practise and study. By using a webcam and VoIP technology, this can assist remote students to diagnosis networking problems immediately. For the provider university, in this case - ECU, the remote access networking classroom provided both tangible and intangible benefits. Only limited trials have so far been conducted. More trials and research in this important area are needed.

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