RUBRIC FOR ASSESSING ICT INFRASTRUCTURE IN MALAYSIA HIGHER EDUCATION

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Access to ICT infrastructure is a key determinant of a higher education institution's ability to deliver teaching and learning effectively. The paper proposes a rubric for assessing ICT infrastructure with regards to the implementation of academic computing in Malaysian higher education institutions. Based on a selection of seven survey questionnaires and rubrics that are used to assess ICT implementation, the paper identifies thirteen performance indicators grouped into four distinct ICT components. The ICT components are computers, network and Internet, display screen technologies and peripherals, and software and information systems. The availability of computers is assessed based on computers to students, Internet-enabled computers to students, computers to academic staff and Internet-enabled computers to academic staff ratios. The performance indicators for network and Internet include network specification, Internet bandwidth, wireless coverage and network/Internet performance. Display screen technologies and peripherals cover percentage of classrooms equipped with display screen technologies and types of computer peripherals. Software and information systems encompass performance indicators related to the availability of application software, learning platforms and academic/student information systems. The paper then uses these performance indicators to describe the characteristics of three case higher education institutions representing low, moderate and high level of ICT implementation. The combination of these performance indicators and description of characteristics form the ICT infrastructure assessment rubric.

Academic computing encompasses the utilisation of staff, infrastructure (hardware and software) and services (technology, information content and human resources) which enable and support the management and delivery of academic programmes in teaching, learning and research. Six main areas of academic computing include 1) teaching and learning using ICT, 2) researching using ICT, 3) ICT vision, plan, policies and standards, 4) ICT infrastructure, 5) information services, and 6) ICT institutional support (Mokhtar et al., 2006).

The paper focuses on ICT infrastructure, an area of academic computing. The importance of ICT infrastructure in today's knowledge based environment is as such that McCredie (2003) equates it with older essential technological infrastructures such as electricity and transportation. The absence of the necessary infrastructure, due to its high costs or its perceived lack of importance, forms a barrier to institutions providing ICT enabled education offerings. This may create a digital divide between higher education institutions and consequently the students, and therefore gives an adverse effect on the quality of higher education as a whole (Barone, 2001).

The purpose of the paper is to propose a rubric for assessing ICT infrastructure. It constitutes one step in a series of steps for proposing a framework for assessing academic computing in Malaysian higher education.

Rubrics as an Assessment Tool

According to Pickett (1998), rubrics are sets of categories that define and describe the important components of the areas being assessed. Each category contains a gradation of levels of implementation with a score assigned to each level and a clear description of what criteria need to be met to attain the score at each level. As an assessment tool, rubrics are effective in evaluating institutional performance in areas that are complex and vague. Rubrics can be created in a variety of forms and levels of complexity, however, they all contain common features which focus on measuring a stated objective (performance or quality), use a range to rate performance and contain specific performance characteristics arranged in levels indicating the degree to which a standard has been met.

To identify the performance indicators for the rubric, seven existing survey questionnaires and rubrics used to assess ICT implementation are analysed. The research then proceeds with a case study on three higher education institutions representing low, moderate and high level of implementation. The findings of the case study are used to form the rubric.

Existing Assessment Instruments

The paper refers to existing assessment instruments consisting of four survey questionnaires and three rubrics to identify performance indicators for ICT infrastructure. The instruments are:

a. Campus Computing Project (Asian Campus Computing Survey, 2003)
b. ICT and E-learning in Further Education Survey (Becta, 2004)
c. International Survey-Online Learning: Strategies, Infrastructure & Initiatives (Observatory on Borderless Higher Education, 2004)

d. Implementation of Technology: A Developer's Guide to the Assessment of Progress (WestEd, 1998)
e. Information and Communication Technology in Higher Education (IFIP, 2000)
f. Rubric for Essential Technology Conditions (Nebraska Department of Education, n.d)
g. Asia-Pacific Regional Survey on ICT Use in Education Based on Performance Indicators (UNESCO, 2004)

Performance Indicators

To assess ICT infrastructure in higher education institutions, the research needs to develop or adapt a set of performance indicators. According to Nuttall (1994), there is no agreement on the definition of performance indicators. However, there is a large measure of agreement that performance indicators provide information about the state of a social system. To arrive at a performance indicator, institutions need to collect relevant statistics or to conduct surveys of a particular process. Idrus et al. (1998) suggest a number of ways of measuring performance indicators, including quantitative and qualitative measures. Nuttall (1994) adds there are views that the inclusion of both types of measures allows the performance indicators to portray the full richness and diversity of the process, and focus beyond the trivial and unimportant.

Computers

One way of assessing ICT infrastructure with regards to academic computing is through the number of computers available to students and academic staff. The availability of computers connected to the Internet shows the capacity of higher education institutions to provide access to the Internet and extent of user coverage. The more computers are connected to the Internet, the more the campus community are able to access the Internet as a rich source of information. It also indicates the level of capacity and sophistication a higher education institution has in promoting more accessibility to technologies. The performance indicators are:

a. Ratio of all computers to students (IFIP, 2000; Nebraska Department of Education, n.d; Becta, 2004; UNESCO, 2004; Observatory on Borderless Higher Education, 2004)
b. Ratio of internet-enabled computers to students (IFIP, 2000; Nebraska Department of Education, n.d; Asian Campus Computing Survey, 2003; Becta, 2004;)
c. Ratio of all computers to academic staff (IFIP, 2000; Nebraska Department of Education, n.d ; UNESCO, 2004)

d. Ratio of internet-enabled computers to academic staff (IFIP, 2000; Asian Campus Computing Survey, 2003; UNESCO, 2004; Nebraska Department of Education, n.d)

Network and Internet

The type of network and Internet connection used is a measure of quality of connectivity and signifies the efficiency (speed, quality) of accessing information which may include multimedia resources that take time to download. A fast network and higher Internet bandwidth allow teaching and learning Web-based resources easier to manage. They also enable large volume of research data to be transferred and shared between collaborating higher education institutions throughout the world. The performance indicators are:

a. Network specification (IFIP, 2000; Asian Campus Computing Survey, 2003; Observatory on Borderless Higher Education, 2004; Nebraska Department of Education, n.d; Becta, 2004)
b. Internet bandwidth (IFIP, 2000; Asian Campus Computing Survey, 2003; UNESCO, 2004; Nebraska Department of Education, n.d; Becta, 2004)
c. Wireless coverage (Asian Campus Computing Survey, 2003; UNESCO, 2004; Observatory on Borderless Higher Education, 2004)
d. Network/Internet performance (Asian Campus Computing Survey, 2003)

Display Screen Technologies and Peripherals

Display screen technologies have made significant inroads into teaching practice. According to Becta (2004), ninety-eight percent of colleges in the United Kingdom use data projectors and ninety-one percent use electronic whiteboards. They are commonly used in a role similar to traditional classroom tool. Such use includes using presentation software with display screen technology to replace the use of overhead projector and transparencies. ICT peripherals include devices used with computers for various teaching, learning and research purposes.

The performance indicators are:

a. Classrooms equipped with display screen technologies (Asian Campus Computing Survey, 2003; UNESCO, 2004; Nebraska Department of Education, n.d; Becta, 2004)
b. Peripherals (Asian Campus Computing Survey, 2003; IFIP, 2000; UNESCO, 2004; Nebraska Department of Education, n.d)

Software and Information Systems

The availability of software, learning platforms and academic information systems has become a very important factor in the success of academic computing implementation in higher education institutions. Learning management systems allow online learning environment by enabling the management, delivery and tracking of blended learning (i.e., online and traditional classroom) for academic staff and students. Academic information systems allow institutions to manage academic administration efficiently. They may also integrate with other departments, such as human resources, accounting and e-commerce, so that administrative and supervisory tasks are streamlined and automated. The performance indicators are:

a. Application software (IFIP, 2000; Asian Campus Computing Survey, 2003; UNESCO, 2004; Nebraska Department of Education, n.d)
b. Learning platforms (Asian Campus Computing Survey, 2003; Observatory on Borderless Higher Education, 2004)
c. Academic/student information systems (WestEd, 1998; IFIP, 2000; Asian Campus Computing Survey, 2003; UNESCO, 2004; Observatory on Borderless Higher Education, 2004)

Methodology

The majority of technology assessment rubrics adopt either a 3-point or 4-point scale for the rubric columns. This study adopts a 3-point scale to differentiate the levels of ICT implementation. As for the labelling of the rubric columns, there is no set standard used in the rubrics. Therefore, the three categories of ICT implementation are descriptively labelled as low, moderate and high to represent the lower, middle and upper tier of the rubric scale.

To identify the detail rubric description for each level, a case study was conducted on three higher education institutions. These institutions are initially selected to represent the low, moderate and high level of ICT implementation based on the ICT information provided by the institutional websites and how they are utilised to disseminate information. In general, the website for low level institution provides limited static information and is largely focused on the programmes on offer. The website for moderate level institution provides a fair amount of static and dynamic information. The website for high level institution provides a large amount of static and dynamic information and incorporates online applications.

At all three institutions, personal interviews were conducted involving the ICT management.

Findings

Using the performance indicators identified in the previous section, the findings from the case study are described based on low, moderate and high levels of ICT implementation in the respective institutions.

Computers

Low: The ratios of computers to students and Internet-connected computers to students are at 1:9 and 1:12 respectively. Many of the computers are also quite old where almost half of them have been used for more than three years. In addition, there is a very restrictive ICT policy that limits student access to computers to only scheduled class hours with the aim to protect the computers from vandalism and misuse. Therefore, the computer labs are only accessible to students with courses requiring them to use the computers. As for academic staff, the ratio of computers to academic staff is at 1:5. One desktop computer is commonly shared between groups of four to six academic staff. Only computer lecturers and head of departments have better access to computers with the ratio at 1:2. As for notebook computers, the number is much less where one is shared between ten academic staff. Notebook computers are only used for presentation during classes or special occasions.

Moderate: As ICT develops, the availability of computers to students and academic staff is much better. The ratios of computers to students and Internet-connected computers to students are at 1:4 and 1:8 respectively. Many of the computers are also quite new where seventy-five percent of them are only one to two years old. The policies on computer use are generally permissive in nature, where they allow the campus community to utilise the campus ICT facilities and resources for educational reasons. As for academic staff, the ratio of computers to academic staff is at 1:3. One desktop computer is commonly shared between groups of two to four academic staff. Only computer lecturers and head of departments have better access to computers with the ratio at 1:1. As for notebook computers, one is shared between six academic staff. Notebook computers are frequently used by academic staff for delivery of lectures and student presentations.

High: The ratios of computers to students and Internet-connected computers to students are both at 1:3 (all computers are Internet-connected). The ratio is also better than the mean average in colleges in the United Kingdom where the ratios are at 1:4.4 and 1:4.3 respectively. As for computer per academic staff, the ratio is at 1:1, similar to the mean average for permanent academic staff in the UK (Becta, 2004). The policies on computer use are generally inclusive in nature, where the main purpose is to get the whole campus community to fully utilise the campus ICT facilities and resources for educational reasons, either by

encouragement or enforcement. However, due to the high integration of ICT in all courses, the excellent computer per student ratio is just enough to fulfil the high demand from students. On peak seasons during the semester, all available computers are fully used for ten to fourteen hours per day, five days per week. As a result, many computers are under heavy strain and the rate in which the computers need repairs and maintenance is high. To ease this problem, the purchase of additional computers is expected within the year and this will improve the computer to student ratio to 1:2.

Network and Internet

Low: The campus network in the institution is based upon a mixture of 10MBps and 100MBps Ethernet technology. Only half of the computers are networked. To access the Internet, only one computer lab and academic staff computers have connection to the Internet. The campus uses 1Mbps Internet connection via Streamyx broadband which is based on best effort service. From observations and interviews with academic staff and students, access to the Internet is very slow unreliability is a frequent problem. As for wireless network, there is no coverage whatsoever.

Moderate: The campus network in the institution is based upon 100MBps Ethernet technology. All computers are connected to the campus network and half of them have Internet access. The campus uses 2Mbps Internet connection via Streamyx broadband which is based on best effort service. From observations and interviews with academic staff and students, the biggest constraint on Internet use is the slow access especially during peak hours. The Internet broadband service is relatively slow during working hours due to the sharing of the same node by many other surrounding sites. In addition, the available bandwidth is not sufficient to serve many simultaneous Internet access by students and academic staff. Wireless network coverage is currently at twenty-five percent of total learning area. Due to the increasing demand for Internet access and the number of academic staff and students owning their own notebook computers, there is a plan to increase the Internet bandwidth to 4Mbps and the wireless coverage to fifty percent within two years time.

High: The campus network in the institution employs a mixed Gigabit and 100Mbps Ethernet technologies. All computers are connected to the campus network and half of them have Internet access. The campus uses 4Mbps Internet broadband connection. The performance is good where access to the network/Internet is always smooth without appreciable delay. However, there is a plan to double the Internet bandwidth to 8MBps within three years due to the projected increase in the number of students and academic staff. In addition, the institution is moving towards ICT based learning environment based on ICT and technology integration where ICT is used in parallel with traditional learning

(e.g. using multimedia courseware, curriculum website, computer modelling, etc. to complement traditional lecture mode) as well as to enable flexible learning (e.g. e-learning for independent, self-paced, flexible time, remote location learning). Wireless network coverage is currently at fifty percent of total learning area. Due to its successful computer notebook ownership programme for students, the institution plans to increase wireless coverage to eighty percent of the total learning area.

Display Screen Technologies and Peripherals

Low: The display screen technologies used are mainly LCD projectors. However, the number of projectors is very limited where one LCD projector is shared by ten academic staff. Many academic staff still use the traditional overhead projectors to deliver their lecture. Due to the limited access of the projectors, many academic staff are disenchanted in using ICT technology as they have to compete with each other to have access to the technology. To make matters worse, they have to go back to older technologies if their attempt to have access to computer notebooks and LCD projectors failed. As for IT peripherals, they are made up of mostly printers although there are a few units of scanners, digital cameras and audio/video recorders for use by the administration and academic staff.

Moderate: The display screen technologies used are by large LCD projectors and a few units of electronic whiteboards. The LCD projectors are not permanently mounted in classrooms. They are portable in nature with one LCD projector is shared by four academic staff. With this reasonable access to this ICT display screen technology, an increasing number of academic staff have started to use presentation software with display screen technology to replace the use of the traditional overhead projector and transparency. A few electronic whiteboards are situated in certain locations such as the lecture theatre and seminar rooms. As for IT peripherals, students and academic staff have access to a variety of peripherals such as printers, scanners, digital cameras and audio/video recorders.

High: The display screen technologies used are LCD projectors and a few units of electronic whiteboards. Altogether, fifty percent of classrooms are equipped with LCD projectors. With the good access to such facility, many academic staff use presentation software with LCD projector to replace the use of the traditional overhead projector and transparency. In addition, with the wide wireless coverage, many academic staff deliver teaching materials stored in the network or accessed from the Internet. A few electronic whiteboards are situated in certain locations such as the lecture theatre and seminar rooms. As for IT peripherals, students and academic staff have good access to a wide range of peripherals such as printers, scanners, digital cameras, audio/video recorders,

portable devices, specialised devices for research and instructional purposes, computer conferencing facilities.

Software and Information Systems

Low: The applications available to all students and academic staff are office applications such as word processing, spreadsheets, databases and presentation software. Subject specific software is only available to certain students and academic staff based on course requirements. No online learning platform exists at the institution. As for academic information system, academic and student data are stored mainly in spreadsheets and separate databases. Processing of information is manually done using the computer. Automation is virtually none existent.

Moderate: The application software available to students and academic staff are office applications, subject specific software, multimedia authoring and video/audio production and web tools. The online learning platform is generally made up of web pages on campus Intranet and learning material files stored in public folders on the campus network. The utilisation rate by academic staff and students is still relatively low at approximately twenty-five percent. As for academic information system, it encompasses mainly registration and examination functions. Access to the system is largely limited to administrative staff.

High: The application software available to students and academic staff are office applications, subject specific software, multimedia authoring and video/audio production, web tools, collaborative and conferencing, and specialised software for instruction and research. The institution also has an agreement with a leading software company to allow academic staff and students to make copies and install software to their own computers. The learning management system used in the institution was customised in-house using open source technologies. It has been used since 2004 and provides teaching and learning support material, online submission and tracking of assignments, online forums and e-communications. The administrator for the learning management system puts the utilisation rate by academic staff and students at approximately ninety percent. As for academic information system, it encompasses a variety of academic and student functions. Some of the functions have become paperless. Specific functions can be access by staff and students from the Intranet and Internet.

Summary and Conclusion

The findings of the case study is summarised by the rubric in Table 1. In general, the institution with low level of ICT implementation has insufficient number of

computers, slow network with low Internet bandwidth, limited display screen technologies and peripherals, and without a proper learning portal and academic information system. Institution with moderate level of ICT implementation has sufficient number of computers, reasonable network and Internet connection with some wireless coverage, moderate access to display screen technologies and peripherals, and a learning portal and academic information system with basic functions. Institution with high level of ICT implementation has excellent ratio of computers, good network and Internet connection with wide wireless coverage, a wide range of peripherals and excellent display screen facilities, and an established learning portal and integrated academic information system.

The rubric proposed by this paper is not in any way an absolute description for all higher education institutions in Malaysia. However, it gives a good description of typical institutions regarding their implementation of ICT. This rubric can be used as a basis to form questionnaire for surveying higher education institutions in Malaysia. With data from a large number institutions, statistical analysis such as factor analysis and Cronbach's alpha can be used to reduce the number of performance indicators to only the ones that have high factor loadings (discriminating factor) and to achieve construct reliability.

Table 1: Rubric for assessing ICT infrastructure

Computers	**Levels of Implementation**		
	Low	**Moderate**	**High**
Ratio of all computers to students	1:9+	1:8 to 1:4	1:3 or better
Ratio of internet-enabled computers to students	1:9+	1:8 to 1:4	1:3 or better
Ratio of all computers to academic staff	1:5+	1:2 to 1:4	1:1 or better
Ratio of internet-enabled computers to academic staff	1:5+	1:2 to 1:4	1:1 or better
Network and Internet	**Levels of Implementation**		
	Low	**Moderate**	**High**
Network specification	10 MB Ethernet or less	100 MB Ethernet	Gigabit Ethernet or better
Internet bandwidth	Dialup or broadband up to 1 MBps	Broadband, 2 to 7 MBps	Broadband, 8 MBps or better
Wireless coverage	Less than 25% of learning area	25% to 50% of learning area	More than 50% of learning area
Network/Internet performance	Slowness/unreliability a frequent problem	Generally works well, but slow at busy times	Always smooth without appreciable delay
Display Screen Technologies and Peripherals	**Levels of Implementation**		
	Low	**Moderate**	**High**
Classrooms equipped with display screen technologies	Less than 25% of classrooms	25% to 50% of classrooms	More than 50% of classrooms
Peripherals	Mostly printers.	Printers and a other peripherals such as scanners, digital cameras and audio/video recorders	A wide range of peripherals such as printers, scanners, digital cameras, audio/video recorders, portable devices, specialised devices for research and instructional purposes, computer conferencing facilities.

Table 1: Rubric for assessing ICT infrastructure (continued)

Software and Information Systems	**Levels of Implementation**		
	Low	**Moderate**	**High**
Application software	Office applications (word processing, spreadsheets, databases and presentation software)	Office applications, subject specific software, multimedia authoring and video/audio production, web tools	Office applications, subject specific software, multimedia authoring and video/audio production, web tools, collaborative and conferencing, and specialised software for instruction and research
Learning platforms	None available	Web pages on campus Intranet and learning material files stored in public folders on network	Commercial or customised open source learning management system offering a wide range of functions
Academic/student information systems	Academic/student data are stored mainly in spreadsheets and databases.	Academic/student information systems are limited to mainly registration and examination functions. Access is largely limited to administrative staff.	Academic/student information systems encompass a variety of academic/student functions. Some of the functions have become paperless. Specific functions can be access by staff and students from the Intranet/ Internet.

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