CHAPTER TWO

REVIEW OF LITERATURE

2.1.   Introduction

This chapter contributes to the discussion on the models and theories for assessing success factors of Information Systems (IS) such that the IS Success model is proposed to evaluate the performance of digital libraries. The focal attention is given to past studies related to models and theories to evaluate the success of Information Systems, research on digital libraries ranging from user awareness of digital libraries, evaluation of digital libraries from users' perspectives, to impact and usability of digital library systems. These previous literature reviews are central to the understanding of not only the taxonomy of the IS Success model and digital libraries' development, but also to learn what can be drawn from the previous findings of studies on the evaluation of digital libraries. The aforementioned focal points of this chapter are essential in order to theoretically conceptualise and analyse the performance of digital libraries based on IS Success. This will lead to the analysis of identifying the salient characteristics or measures that are expected to influence the success of digital libraries in academia. This critical review is carried out by reviewing past articles and journals, books, theses and dissertations, obtained online and offline.

The chapter begins with a discussion on the Information System evaluation studies and taxonomy of IS Success models and theories from different authors in Section 2.2. In line with the research scope, the discussion extends to definitions of the digital library and its development in Section 2.3. The following sections review the

role of Information System infrastructures as a platform for digital libraries and some issues with digital libraries, in Section 2.4 and 2.5 respectively. Review on the users' awareness of digital libraries is highlighted in Section 2.6.

In Section 2.7 the past studies related to the Information System evaluation models learned from the literature including the Task-Technology Fit, IS Success, IS-Impact and IS Usage for Information Provisioning are examined. The subsequent Section 2.8 presents discussions on the usability models, studies of the IS Usage (Section 2.9), performance indicators of digital libraries (Section 2.10) and some conceptual models to evaluate digital libraries (Section 2.11). Section 2.12 elaborates the considerations taken in the past studies to analyse the performance of digital libraries, followed by the description of research variables used in the digital libraries' assessment (Section 2.13). The final section summarizes the chapter.

In the following the taxonomy of digital libraries with respect to their development and issues are reviewed.

2.2. Type of Libraries

The term "digital libraries" has existed since early 1990's, but no conclusive definition prevails due to the fact that different people seem to adopt them for their context of usage (Gard, 2001). The digital library has emerged as a result of evolution in computing and Information Systems technologies, and has been introduced in universities and the general public. It is not only a convenient access to and retrieval of resources, but also easier acquisition of full-text materials as compared to traditional library services (Joo and Lee, 2011).

The fundamental infrastructure of digital libraries has been improved from year to year. The improvement is specifically for enhancing the quality of information retrieval, from query expansion to collaborative filtering or multi-faceted browsing (García-Crespo et al., 2011). While information retrieval began in the 1950s (Choi and

Rasmussen, 2009), it was three decades later that digital libraries emerged. Since then, libraries are increasingly proffering their materials digitally. Owing to the rapid growth of IT and ICT, the evolution of such information retrieval systems continues in the era of networked information society. Blending the IT and ICT, a web-based Information System like a digital library is another product that has recently been given enormous attention, especially by public or varsity librarians, practitioners, as well as IT developers. Xie and Joo (2009) asserted that although academic users rely on both electronic and printed resources, they depend more on electronic resources. This is parallel with today's desirability and requirements particularly in education, which is to gain online academic resources. Living in an information society era, Thanuskodi (2011) emphasized the tremendous impact given by the Internet on the academic activities particularly to the faculty's staff, students and researchers.

There are several definitions of digital libraries in the literature. Chowdhury and Chowdhury (2003) highlighted that many of the definitions were formulated in the course of digital library research projects. The digital library is a person-centric system as opposed to a generic collection and service, and as a facilitator of communication, collaboration and interactions; these are two important points about the nature of emerging digital libraries (Chowdhury, 2010).

Borgman (1999) analysed a number of definitions of digital libraries and summarise the definitions into two major classes, one is from digital library researchers (mostly scientists and engineers in the US) and another from library and information professionals. Looking at these two different fields of background, digital libraries' development and intention of use are unified with the requirements set forth and tailored to the community that they are serving.

According to Marchionini (2000), digital libraries marry the missions, techniques and cultures of physical libraries with the capabilities and cultures of

computing and telecommunication. However, Digital Library Federation, DLF (1998) provides an inclusive definition, as follows:

> *Digital libraries are organisations that provide the resources, including the specialised staff, to select, structure, offer intellectual access to, interpret, distribute, preserve the integrity of, and ensure the persistence over time of collections of digital works so that they are readily and economically available for use by a defined community or set of communities.*

Chen (2000) stressed on the access to information and suggested various methods, tools and techniques that could facilitate improved access to information in digital libraries. Reich and Winograd (1995) stated that Stanford digital library research team defined digital library as a coordinated collection of services that are based on collections of materials, some of which may not be directly under the control of the organisation providing a service in which they play a role. The latter part of this definition reflects an important characteristic of digital libraries (Chowdhury and Chowdhury, 2003).

The digital library is an essential service to help users find and access information resources in the networked information society. Many research and development projects on digital libraries have been carried out by the ICT research communities (Sugimoto, 2005). Moreover, as the amount of digital information continues to increase, the management of data quality in digital libraries will be one of the more important aspects of digital library administration (Beall, 2005).

Based on the current implementation of digital libraries', issues and concerns related to the performance of digital Information Systems may not be widely researched. Research on the evaluation of digital libraries is in its infancy (Mittal and Mahesh, 2008). Mittal and Mahesh (2008) argued that researchers are still investigating the *who, what, when, how* and *why* of evaluation studies. DL quality and evaluation are a much underrepresented research area in the digital library literature, according to

Goncalves et al., (2007) who emphasized that the first person to consider such a problem is Saracevic (2000) where the latter argued that any evaluation has to consider a number of issues such as the context of evaluation, the criteria, the measures/indicators, and the methodology. Since his analysis concluded that there are no clear agreements regarding the elements of criteria, measures/indicators, and methodologies for DL evaluation, Fuhr et al. (2001) proposed a descriptive scheme for DLs based on four dimensions: data/collection, system/technology, users and usage.

Since libraries are increasingly providing digital services, there has been a phenomenal increase too in the number of digital libraries. Many existing areas of research in DLs are being carried out to meet the pace of demand in information retrieval, either from the user perspective or the system perspective (Mohd Razilan, Fatimah and Diljit, 2008). The beginning of discussions on digital libraries was in the 1960s, however Saracevic (2004) claimed that the research, development and practice related to digital libraries really took off in the middle of the 1990s. He reported that the historical growth of digital libraries was phenomenal where over the decades, thousands of digital libraries in a variety of forms have been built globally and functioning operationally. Tammaro (2008) also reported that the first project using digital library applications in Italy was in early 1990 (by research institutions and academicians), but the first national Italian Digital Library project started in 1999.

Lee et al. (2007) reported that the figure of known digital libraries developed through the National Science Foundation's National Science Digital Library programme (as of 2004) were 356. They also found from the People's Daily Online (published in year 2006) that the number of digital libraries in China exceeded 1,000 in 2006. Without mentioning the exact figures, they stated (based on the number of published journal articles and reports in conference proceedings) that the number of digital libraries and repositories in India was growing quickly. However, they concluded that coupled with

the fact that India has a large number of educational and research institutions, the number of digital libraries and repositories available in the country today was still fairly low.

The notion of "digital libraries" (DLs) is subject to a broad range of definitions. Different audiences associated with DLs have different interpretations; they evaluate a digital library differently and use different terminologies. It is interesting to discover that there is no agreed definition of what a DL is, as claimed by Blanford et al. (2007). They refer to Fox et al. (1995:24) who stated that:

The phrase "digital library" evokes a different impression in each reader. To some, it simply suggests computerization of traditional libraries. To others, who have studied library science, it calls for carrying out of the functions of libraries in a new way.

On one hand, DLs are considered to be related to physical libraries performing similar functions, thus creating a hybrid library (combining traditional and electronic resources). But on the other hand, DLs are considered to be knowledge repositories, and services, organised as complex Information Systems. For example, global information repository projects are devoted to the accumulation of digital forms of information related to the Earth, universe, art, environment or humans (UNESCO, 2003).

DLs provide essential cyber-infrastructure, moving us toward knowledge environments geared toward individual needs, as well as helping us address global concerns, and digital libraries have already evolved since their inception in early 1990s (Fox, Goncalves and Shen, 2005). Reviews on the evolution of digital libraries can be referred to Mohd Razilan, Fatimah and Diljit (2008).

The following subsections present the definition and taxonomy of the evolution from physical libraries to virtual libraries.

2.2.1. Physical Libraries

Peek (1998) claimed that people do not have much problem defining the term "library." She defined library as a collection of information, usually databases called books, held in specific locations. Moreover the presumption of the information; to be shared and made available to a specific community and not to the entire world is emphasized as well. Whilst Pomeranzt and Marchionini (2007) added that in physical libraries, due to the fact that books and other physical information resources and people occupy physical space, libraries have evolved into complexes of buildings, rooms, and mobile spaces in which books and other materials and people come together; and these spaces are manifestations of the library as a place. Nurnberg et al. (1995) once stated a simple definition of the physical library: one that '*deals with physical data*'.

2.2.2. Hybrid Libraries

The phrase "hybrid library" rather than digital library has been used by some authors (Tedd and Large, 2005), especially in Europe, to emphasize that the collection may include non-digital documents alongside digitised documents. Hybrid libraries are designed to bring electronic and paper-based information sources together in the context of a working library, providing systems and services in both the electronic and print environments (Rusbridge, 1998; Pinfield et al., 1998). Rusbridge (1998) also claimed that the physical library that maintains digital components, such as digitised representations of physical materials in its collection, or subscriptions to databases or other electronic resources, can be included as hybrid libraries.

2.2.3. Virtual Libraries

Graham (1995) posited the virtual library as a companion term to digital library was brought forth by the National Science Foundation in 1994. While Koltay and Boda

(2008) defined virtual libraries as resources available on the Internet outside the given library, where the resources provided are free, either with or without permission. However, Watseins, Calarco and Ghaphery (1999) contended that both terms (virtual library and digital library) have been used narrowly to define the quantity of databases available for use at a given time.

2.2.4. Digital Libraries

It is not clear when the first digital library came into being, but the concept did not appear until the late 1980s (Li, 2005). Li (2005) claimed that the emergence and development of digital libraries at this stage were driven by two main forces: (1) digital technological development, especially in multimedia and networking, capable of offering more efficient and new ways in information processing and management; (2) people wanting to better share important information like library materials, scientific databases in education and research. Despite the different definitions of digital libraries, one of the most accepted definitions is by the Digital Library's Federation, in 1998 (Waters, 1998; Koltay and Boda, 2008). While some other definitions have been offered such as by Bhattacharya (2004), who defined digital libraries as managed collections of digital objects, created or acquired according to the principles of collection development, in which information is stored and distributed in digital form with the associated value-added services, necessary to allow users to retrieve and exploit the resources just as in a traditional library.

An informal way of defining digital libraries was given by Arms (2001): A digital library is a managed collection of information, with associated services, where the information is stored in digital formats and accessible over a network, and the crucial part of this definition is that the *information is managed*. He emphasised that the information is organised systematically to become a digital library collection. While

Witten and Bainbridge (2003) regarded a digital library as a focused collection of digital objects, including text, video, and audio, along with methods for access and retrieval, and for the selection, organisation, and maintenance of the collection.

2.3. Success Measures for Information Systems

IS Success evaluation has been the prime Information System research agenda for the past three decades. It began in the 70's where in recent years hundreds of measures and constructs applied in evaluating the success of Information Systems have been developed by Information System researchers as well as practitioners. The vital facet of evaluating the success of Information System leads to the understanding of the efficacy of the system to its target community. The measurement of the success of the Information System guides the management's decision to take further actions and investment in monitoring, managing and improving the business. Sekaran (2000) emphasised that the theoretical framework is a conceptual model of how one theorises or makes logical sense of the relations among several factors that have been identified as important to the problem. However, it may not suffice to only consider system-wise factors. Information System research is not all about systems and technologies but also on the linkage between the system and human beings. How individuals perceive, believe, learn and evaluate Information Systems are seen as among the complementing needs for evaluating IS Successes. DeLone and McLean's (D&M) IS Success model (1992, 2003, 2004) showed that user attitudes and usage of the system lead to individual performance. Goodhue and Thompson (1995) further developed intrinsic diagnostics for Information System problems by taking a step beyond, but consistent with the D&M Success model. They developed the Task Technology Fit (TTF), a model linking technology and individuals' performance. The most recent research expands the net benefits dimension in the D&M IS Success model known as IS-Impact model (Gable, Sedera and Chan, 2008). The action research methodology was performed in three

rounds of the survey. The first survey is for identifying and refining a set of prominent success constructs; the second is for specifying the constructs from the first survey and the third for confirming the constructs. It was developed based on multi-stakeholder using Enterprise systems.

2.4. Information Systems and Digital Libraries

The basic role of an Information System (IS) is to organize a huge variety of information resources on the Internet. Digital library is a type of public information system where its purpose is to provide some kind of service or support for a public process, or a process involving the general public or society at large. Sundgren (2005) defined *the public* as a collective of people, e.g., the citizens (a.k.a. users) of a society. He added that the concept could be broadened to include collectives in, for example, companies and organisations, which may often have needs vis-à-vis public authorities that are similar in nature to the needs of individual people.

The techniques and designs used for digital libraries' development, deployment (physical network i.e., the hardware on which the DL system is to be deployed) and implementation (the DL's system architecture) should be suited to the digital library environment. Such techniques which include organising, distributing, retrieving and processing information resources on the web are highly dependent on the Information System technology designed and developed in order to make the process of the digital library environment a success. Digital libraries share characteristics of information retrieval (IR) systems so they also need to be evaluated based on the criteria of evaluating IR systems (Xie, 2006). Reeves, Apedoe and Woo (2005) explained that from the *user's* perspective, information retrieval evaluation is appropriately focused on how effectively and efficiently a user's *search* for information meets his or her needs or interests. From the *systems'* perspective, information retrieval evaluation is focused on evaluating the effectiveness and efficiency of the *retrieval system* that is at the core of

any digital library. Therefore, in order to study the performance of digital libraries with reference to Information Systems, information retrieval evaluation should not be ignored or underestimated, as it plays an important role in digital library systems.

Technological infrastructure for digital libraries may not be a difficult area for DL developers as the capability of today's technology is much more advanced than it was ten years ago. Digital library developers have a variety of options to consider which technology to apply when building their digital libraries. Nevertheless, today's DL systems must confront an increasing range of document formats and media, architectural designs for browsing and classification, indexing requirements, and user interface techniques (Buchanan et al., 2005). As far as the technology is concerned, we are now in the digital era and the technology is ready to suit with the digital library system to be developed.

Nevertheless, the main concern is the selection and implementation of digital libraries. As a complex type of public Information Systems, digital libraries have a vision not only in terms of technological infrastructure (Koltay and Boda, 2008) but also as a set of services, based on managerial decisions, related to economic models, intended for specific user communities and offered in the specific institutional settings. In terms of the evaluation of DLs' performance, it is yet prevalent although the use of DLs is widespread. Evaluating the DLs' performance is essential because to be accepted as a digital library provider, DLs should meet the requirements of the communities developing and using the system. DLs' research communities (like Information System / Information Technology / Computer Science experts) are focusing on the development research as well as dealing directly with technology applications or enabling technologies in network infrastructure. DLs practice communities like librarians may also build DLs systems, but they are likely to focus more on the operational side with fewer research activities.

Since DLs are developed for, and maintained by people, their performance in terms of satisfying and meeting certain criteria or requirements as a library provider is significant. With a mushrooming number of DLs developed and used each year, their performance analysis should be carried out especially to merge the requirements or decisions with respect to DLs deployments and implementations, by the respective users from DL communities.

2.5.   Issues in Implementing Digital Libraries

Despite the myriad of advantages of digital libraries over physical libraries, it should be noted that digital libraries have their limitations. Kilker and Gay (1998) argued that digital libraries are embedded in complex social systems, comprising librarians, engineers, funders, scholars and general users. It is clearly seen that different social groups require and adopt different needs of digital libraries, for example, the interface. Until now, there is still no accepted standard for interfaces (e.g., for browsing, searching and language used) of digital libraries due to the fact that there are a variety of user types of digital libraries. Jeng (2005) stressed that interface is one of the most important aspects of usability as it is the medium that users use to communicate and interact with the system.

Arms (2001) defined digital library as a managed collection of information, with associated services, where the information is stored in digital formats and accessible over a network. The key point here is that a collection of information is managed. As noted by Witten, Bainbridge and Boddie (2001), a collection of information typically comprises several thousand or several million documents. The issue is how technology in Information Systems can be applied in managing collections of digitised information by different types of users. It is again reported by Witten (2005) that digital libraries posed an inherent tension between the technologist's desire for advanced solutions

using the latest and greatest hardware and software, and the librarian's desire for wide, cross platform availability and long-term preservation.

Among the information retrieval community, precision and recall are two well-known parameters best used as measures for assessing retrieval system performance. However Blandford and Buchanan (2003) contended that these might not the best and only performance indicators. This is due to the variety of uses of DLs which serve different purposes to different users.

Another issue which cannot be underestimated is that many digital library implementations had not fully recognised that people adapt differently to new technology (Gard, 2001). This claim is also supported by Kibirige and DePalo (2000) where they suggested that categories of users vary in their information-seeking behaviour and expertise. That is why research on digital libraries has moved from the technical aspects of building digital libraries to designing digital libraries to satisfy user needs (Xie, 2006).

In addition to serving as an evaluation tool for DLs, the *usage* and *usability* of the system have to be made clear. However, the Information Systems literature has shown that some Information Systems models are difficult to interpret. Consequently, in evaluating a system such as DLs, the usage and usability aspects are seen as key proximate determinants that drive the success of digital libraries.

2.6. Users' Awareness of Digital Libraries

Digital library research has developed rapidly over the past decade, and millions of dollars have been spent on building digital libraries. However, previous research indicates that many potential users may still not use digital libraries (Thong, Hong and Tam, 2002). Research on users' awareness of digital libraries has received increased attention in recent years. Farooq et al. (2008) reported that (by referring to Hansen and Järvelin, 2005), the concept of awareness of digital libraries, and for their longer term, is

only the beginning. Through the case study of awareness of digital resources in libraries, Asemi and Riyahiniya (2007) concluded that there is a direct relationship between the scales of awareness and use by the user. Schmidt (2002) claimed that awareness of digital libraries has taken up many meanings and interpretations, and highly depends on the context for which they are being used. But in the context of awareness study of human- computer interaction (HCI) and computer supported cooperative work, they have existed for 15 years (Dourish and Belloti, 1992) but not in digital libraries (Farooq et al., 2008).

Findings from the University of Rhode Island (2006) indicated that even though awareness of and experience with digital repositories is low, respondents are willing to investigate further and recognise a variety of benefits of a centralised system. The main indication here is users' awareness of digital library systems is in fact still low among students. Asemi and Riyahiniya (2007) pointed out that scholars, students, teachers and researchers actively seek current information through the various media available in the libraries. They emphasised that if users were aware of one helpful resource, it would usually lead to greater use of that resource.

Another study by Atilgan and Bayram (2006) on the level of awareness of digital libraries of the academic staff at Ankara University, Turkey showed that the majority of their respondents knew digital library resources existed in the university. Among the academic staff selected in their study, the level of awareness distribution showed associate professors were the highest ranking group followed by assistant professors, but instructors were the last. Their study showed that awareness of digital libraries was more prominent among senior staff. However, findings from Maly et al. (1999) indicated that a large number of users' access of NASA publications were not through the NASA Digital Library interface, but through general search engines like Yahoo, AltaVista, and Lycos. They admitted that the abstracts and reports in the digital

library were indexable by crawlers and spiders, and users had to formulate complex queries to search through those search engines instead of accessing the collections through the digital library's own interface.

While Tsakonas, Kapidakis and Papatheodorou (2004) noted that the predominant interaction process in complex Information Systems, such as digital libraries, is full of revisions, filtering and judgmental actions that cannot be represented in idealistic "one-off", linear interactions. According to Spink et al. (2000), linear kinds of interaction are more unstructured means of information management, like search engines, where the nature of the tasks encourages simplified interface structures and items' representations, and leads to the limited use of advanced features, indicating users' lack of information literacy and awareness.

Findings from a case study conducted by Tammaro (2008) in Italy on users' perceptions of digital library services indicate that users have different perceptions with regards to digital libraries and that they tend to use the services of more than one cultural institution. Her study also reveals that users often do not know how to use the libraries and are unaware of all of the services offered. Nevertheless, overall, there is a positive attitude towards digital libraries.

In determining the users' awareness of digital libraries, this study will refer to the works of Hansen and Järvelin (2005). In their study, they described awareness in more formal ways and classified it into three categories:

1. *Awareness of People*

   This category of awareness refers to knowing about one's colleagues.

2. *Awareness of Activities*

   This category of awareness refers to sharing the same need for information such as search strategies.

3. *Awareness of Objects*

This category of awareness refers to accessing different types of resources such as sharing retrieved objects.

In the following section, the discussion continues on the review of the Information Systems literature, by providing several assessment models for IS Success.

2.7. Information Systems Evaluation Models and Theories

Assessing the success of Information Systems have been an ongoing research topics in the field of Information Systems for more than three decades (DeLone and McLean, 1992; Myers, Kappelman and Prybutok, 1998; Alberto and Gianluca, 2007; Gable, Sedera and Chan, 2008; Wijesinghe, Sedera and Tan, 2009). Due to the emergence of different types of systems used by different communities, evaluating the success of Information Systems seems to be tailored to the requirements based further on the purpose of its use. Information Systems may be used to support activities such as social processes (medical entertainment), business tasks (industry, trade) and education. Khoo and MacDonald (2011) noted that different definitions of digital libraries shaped the evaluation approaches in different ways. For this reason, the past three decades have witnessed a variety of performance measures developed to evaluate Information Systems by different authors with different aims and perspectives of assessments.

This section begins by reviewing five main branches of Information Systems research streams in evaluating the success of Information Systems for the past three decades.

2.7.1. Technology Acceptance Model (TAM)

Davis (1986) developed TAM for software adoption. This is the first Information Systems research stream where the research seeks to understand the dynamics of human decision making in the context of accepting or resisting technology, and it is widely

applied in Management Information System (MIS) (Morris and Dillon, 1996). The theory has been refined by many researchers who studied the impact of perceptions of a system on its acceptance (Hallonen et al., 2009). Morris and Dillon (1996) emphasized that user acceptance is defined as the demonstrable willingness within a user group to employ information technology for the tasks it is designed to support. The measure incorporates the usefulness of the Information System that is based on how a system can fit and support the community's environment. On the other hand, lack of this acceptance will somehow initiate a barrier to the success of the evaluated Information System. A key dimension for another generalized theory called Theory of Reasoned Action (TRA), is based on psychological determinants – *perceived usefulness, perceived ease of use* and *usefulness to whom*. It was produced by Fishbein and Ajzen (1975).

2.7.2. Task-Technology Fit Model (TTF)

The Task-Technology Fit (TTF) model links technology fit and user attitudes. Goodhue and Thompson (1995) believed that this linkage has brought complementary streams of two types of research: user attitude and technology fit. Their model is consistent with the D&M IS Success model.
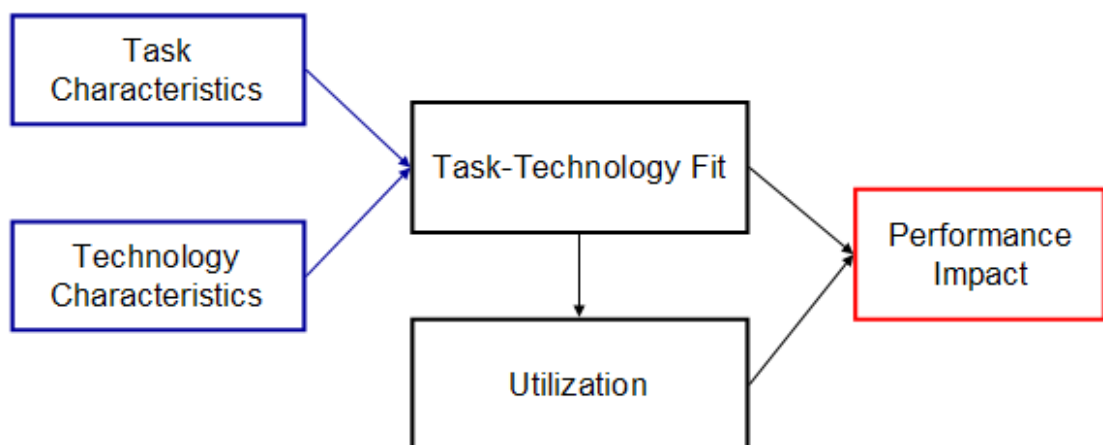

Figure 2.1: Task-Technology Fit (TTF) model (Goodhue and Thompson, 1995)

2.7.3. Information System Success Model (IS Success)

DeLone and McLean (1992) introduced a model to assess the success of Information Systems, which is also known as the D&M model. This model has become the standard tool in Information Systems research for assessing Information Systems using six main dimensions, namely *system quality, information quality, use, user satisfaction, individual impact* and *organizational impact*. Due to the considerable contributions in Information Systems research, they later updated their model in 2003 and 2004 by adding *service quality* and combining *individual impact* and *organisational impact* to become *net benefits*. DeLone and McLean (2003) referred to *net benefits* as the impact measures from work group impacts, organisational and industry impacts, consumer impacts, and societal impacts.
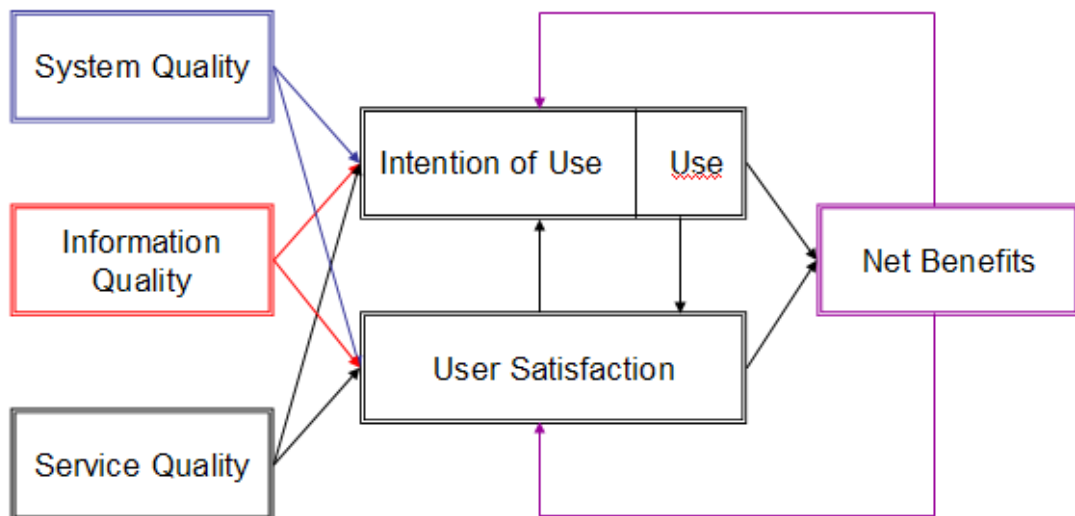

Figure 2.2: DeLone and McLean (D&M) IS Success model (DeLone and McLean, 2004)

Source: Ambrose, Rai and Ramaprasad (2006)

2.7.4. Information System Impact Model (IS Impact)

The most recent model in evaluating the IS Success is the Information Systems impact model or IS-Impact model by Gable, Sedera and Chan (2008). The model extends the

net benefits stream from the D&M IS Success model which embraces *impacts* and *quality*. *Impacts* are based on impacts to date whilst *quality* are approximates of anticipated impacts. Three series of survey with subjects of multi-stakeholders using the Enterprise Systems were completed, which constituted identification survey, specification survey and confirmation survey. The identification survey was to identify the dimensions and measures of IS Success, followed by specification survey which was to specify the dimensions and measures derived from the identical survey. The last survey was done to validate rigorously the dimensions and measures using statistical approaches.
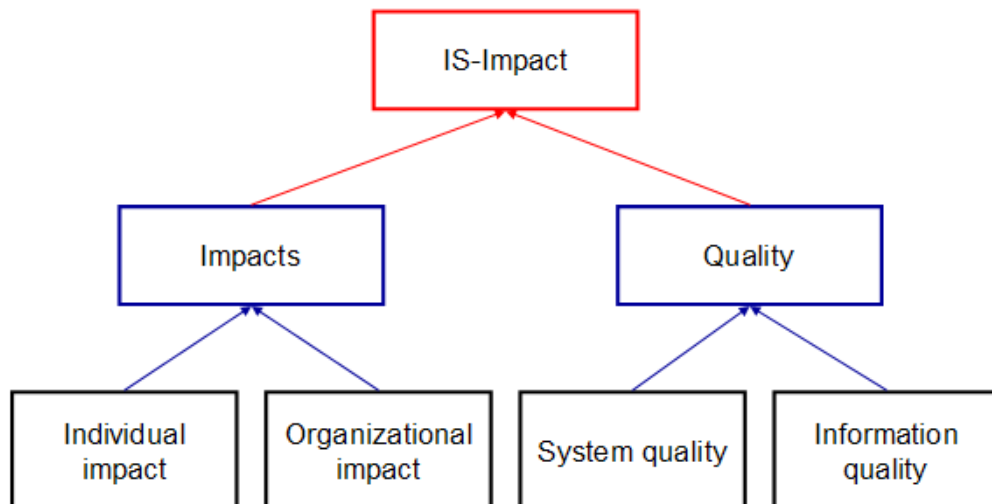

Figure 2.3: IS Impact model (Gable, Sedera and Chan 2008)

Source: Gable, Sedera and Chan (2008)

The discussion continues by tabulating the taxonomy of IS Success models developed by different authors from the year 1970s to the year 2000s (Table 2.1).

Table 2.1: Evaluation models for IS Success

	Year	Model and Description	Author(s)
1.	1975	Theory of Reasoned Action (TRA) - a generalised theory relating between the beliefs and behaviours. - key dimensions: *behavioural intentions* and *rationality*.	Fishbein, M. and Ajzen, I.
2.	1986, 1989	Technology Acceptance Model (TAM) - a specification of TRA for the case of adopting technology. - key dimensions: *usefulness, ease of use* and *usefulness to the targeted community*.	Davis, F. D.
3.	1995	Task-Technology Fit (TTF) - a model linking the technology and individual's performance. - key dimensions: *utilization focus, fit focus,* and *combination utilization and fit*.	Goodhue, D. L. and Thompson, R. L.
4.	1992, 2003, 2004	Information Systems Success (IS Success) - a standard tool for measuring the IS Success uses complex inter-related identified dependant variables. - key dimensions: *system quality, information quality, service quality, use, user satisfaction, net benefits*.	DeLone, W. H. and McLean, E. R.
5.	2008	Information Systems Impact Model (IS Impact) - using backward (impact) and forward (quality) measures identified from three rounds of survey (identification survey, specification survey and confirmation survey) - key dimensions: *impact (individual impact and institutional impact) and quality (system quality and information quality)*	Gable, G., Sedera, D. and Chan, T.

Table 2.1 exhibits the assessment models for IS Success that have been discussed in the Information Systems literature for the past three decades. With authors having different conceptualisation of the Information Systems constructs, it is difficult to get a consensus on what presents the best measures in assessing IS Success.

2.7.5. Information Systems Usage for Information Provisioning (IUIP)

Information System usage has many interpretations among Information Systems researchers. Four main paradigms have been identified (Seddon, 1997; Burton-Jones and Straub, 2006): IS for Decision-making, IS Implementation, IS Acceptance and IS Success. The IS Success refers to the Information Systems usage, where it is a process

leading to individual impact, as well as to organizational impact. Lack of holistic definition of usage, lack of theoretical grounding and issues associated with measures of usage are among the concerns on the Information Systems usage issues found in the Information Systems literature (Burton-Jones and Straub, 2006). Nonetheless, Ambrose, Rai and Ramaprasad (2006) introduced an evolution of the Information Systems usage concept by conceptualising and defining the usage construct for information provisioning. Despite the ambiguous empirical support of Information Systems usage in IS Success nomological network, Ambrose, Rai and Ramaprasad (2006) developed a formative construct of Information Systems usage comprising three dimensions—usage for content breadth, usage for content depth and usage of content interaction dynamism. Figure 2.4 displays the construct of Internet usage for information provisioning (IUIP).

Figure 2.4: The three formative constructs of the IUIP
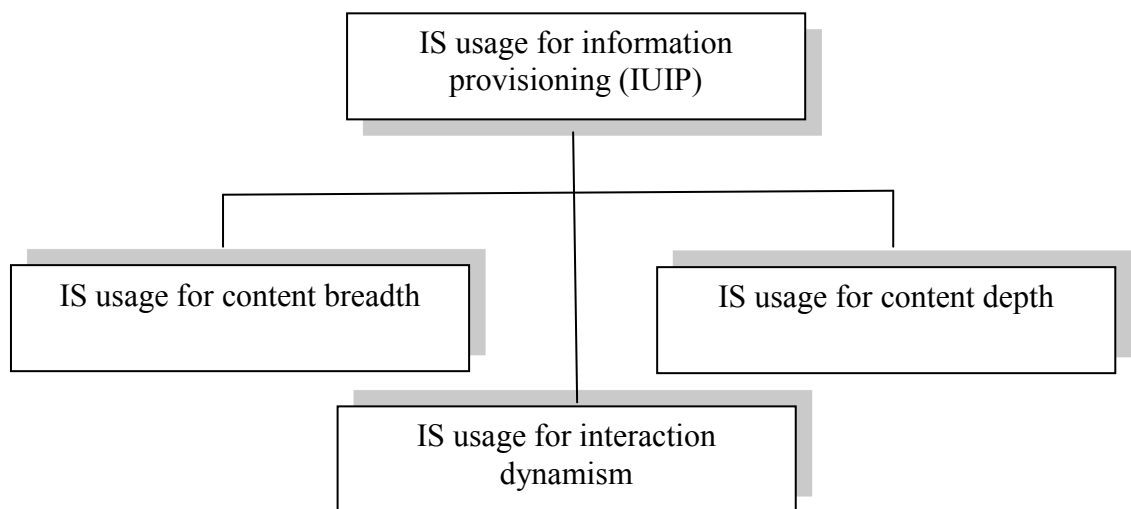
Source: Ambrose, Rai and Ramaprasad (2006)

The development of IUIP was grounded by the theory of Technology-to-Performance Chain (TPC). The conceptualisation of IUIP is based on the *use of system* in the context of diagnostic decision-making. The *usage* constructs included how the system was used to obtain or provide different types of information to satisfy the

information processing needs. Each indicator measured for each dimension was selected based on TPC theory and the construct development was validated in accordance with the formative measurement model procedure. The followinng section proceeds with a discussion of the most widely used models in evaluating digital libraries, i.e., usability techniques.

2.8.   Evaluation of Digital Libraries Using Usability Techniques

Digital libraries are Information Systems designed to serve the targeted user community, to fulfill their needs in relation to information search, access and retrieval. Marchionini, Plaisant and Komlodi (1998) emphasized that all efforts to design, implement, and evaluate digital libraries must be rooted in the information needs, characteristics, and contexts of the people who may use those libraries. As emphasized by Marchionini, Plaisant and Komlodi (1998) and Parandjuk (2010), cited in Cignoli and Liu (2011), users' expectations reflect the interface design best practices advocated in human-computer interaction (HCI) to keep them engaged. With respect to this, evaluation of digital libraries for the usability study is very important to understand the usefulness and usability of the digital libraries to users. As noted by Hariri and Norouzi (2011), a digital library interface needs more attention as it is a gateway to enter into a DL's information environment.

Towards evaluating the digital library system's performance, users' usability is the key factor in understanding the usefulness of the system. As suggested by Bertot, McClure and William (2004), in order to develop evaluation efforts of digital libraries, measures and approaches that include the users should be considered. And that is why in evaluating digital libraries, the focus should be on experiencing the system first. Xie (2008) claimed that the best way to evaluate digital libraries is to actually use them.

The International Standards Organisation (1994) defined usability as;

The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use.

While Nielsen (1993) defined usability as;

It has five attributes: learnability, efficiency, memorability, error recovery, and satisfaction.

Early studies on global digital library usability focused on objective, technical issues such as multilingual support, international character recognition and interoperability (Borgman, 1997; Oard et. al., 1999). The creation of digital libraries and repositories involves the use of suitable software, hardware and content (Mittal and Mahesh, 2008). They reported that hardware was not a major concern, but identified the selection and implementation of digital library and repository software as a problem area.

Frias-Martinez, Chen and Liu (2008) stressed that most of the current digital libraries take a global approach, by which all users are presented with the same interface. They refer to the study by Marchionini, Plaisant, and Komlodi (1998) who emphasized that the global approach may make users feel that it is difficult to locate information, because there is not a match between users' preferences and functionalities offered by digital libraries.

Evaluation methods for usability assessment of academic digital libraries (Jeng, 2005) revealed that interlocking relationships exist among efficiency, effectiveness, and users' satisfaction. Her proposed usability evaluation model comprised effectiveness, efficiency, satisfaction and learnability. A survey on users' perceptions of digital libraries in Italy also found that users have different needs, which correlate to the different goals of the digital libraries' institutions (Tammaro, 2008).

Blandford and Buchanan (2003) argued that as yet there is no consensus on what the key criteria are for evaluating the usability of digital libraries. They reported the term "useful" as generally taken to mean "supporting the required functionality"; in the case of digital libraries, the obvious use is making digital documents available to the appropriate user groups at the time they are needed and in appropriate formats. But Ferreira and Pithan (2005) reported that it is possible to prove, from their usability test study in at the site of a digital library, to analyse information search and use behavior validates and add new perspectives to the analysis of usability aspects.

In Saracevic's (2005) study on evaluating digital libraries, he asserted that a system-centered approach is widely used, where it involves the study of some performance aspects. He suggested including measurements of the effectiveness and efficiency of certain features, or specific designs, or some technological components in the digital library system. Library-centered approaches evaluate the presentation of resources and services with an emphasis on efficiency and effectiveness. On the other hand, user-centered approaches evaluate the quality of the presentation of resources and services; the inclusion of the needs of users or patrons in accessing resources and services (Bertot, McClure and William, 2004).

Xie (2008) pointed out that many questions related to whether users use digital libraries, how they use them, and what facilitates and hinders their access of information to the digital libraries cannot be answered without the evaluation of the existing digital libraries. There is a need to assess the usability of digital libraries in order to evaluate their full potential (Blandford and Buchanan, 2003). The bulk of research on digital library evaluation focus on how users use a digital library, essentially usability studies, to either recommend design principles or improve the existing design (Xie, 2006).

2.8.1. Usability Models

Usability evaluation is concerned with gathering information about the usability or potential usability of a system, in order to assess it or improve its interface by identifying problems and suggesting improvements (Shneiderman and Plaisant, 2005; Ssemugabi and Villiers, 2007).

From the literature, there are various types of evaluation methods applied in usability studies. They include usability testing, log analysis, focus group, analytical evaluation, heuristic evaluation, survey, observational, and experimental methods (Blandford, Buchanan and Jones, 2004; Jeng, 2005; Shneiderman and Plaisant, 2005). These various methods are used depending on the goals of the evaluation. Usability testing is based on formal laboratory settings to test how digital library interfaces support users in completing their tasks, while log analysis involves obtaining users' statistics (users' activities and actions) captured from the digital library's log system. Another popular model is a focus group, where digital libraries' usability information is collected from a group of people who have experience in using them.

Heuristic evaluation originated from Nielsen (1993). This type of usability evaluating consists of a small set of expert evaluators who determine whether a system conforms to a set of usability principles known as heuristics and identifies specific usability problems in the system. Ssemugabi and Villiers (2007) claimed that heuristic evaluation is the most widely used as the usability evaluation model for computer system interfaces. Whilst survey is conducted by distributing questionnaires to targeted respondents (users) in order to obtain feedback on the usability of digital libraries. Observational study is structured observations where the behaviour of a sample of individuals is observed and recorded.

Borgman et al. (2001) emphasized that the objectives of usability studies have shifted substantially. Initially the purpose was to shape human beings to adapt to technology. However, now the objective is to shape the technology to suit human needs and capabilities. Duncker, Theng and Mohd-Nasir (2000) also commented on the importance of colours, forms, symbols, metaphors and language, especially for users coming from different cultural backgrounds, where they claimed that these factors can significantly affect the usability and user-friendliness of digital libraries.

Despite all these usability evaluation models in the usability research area, the holistic intention of the *usability* aspect itself cannot be belittled. In the following section, two main usability dimensions are discussed together with the rationale for why both are important in evaluating the performance of digital libraries, from users' perspectives.

2.8.2. Usability Dimensions

According to Arms (2001), usability comprises several aspects, including interface design, functional design, data and metadata, and computer systems and networks. This was also supported by Jeng (2005) who believed that usability is a property of the total digital library system where all the components should work together efficiently in producing an effective and convenient digital library.

It is learned from the literature that the interface usability dimension is the core form of digital libraries' usability, but there is also another dimension introduced by Kling and Elliot (1994) that can be considered important, that is organizational usability. Their main aim for introducing organisational usability is to assist in the digital library system design so that the dimensions will be addressed in the developed system.

1. Interface usability dimensions

    Many studies on user-based measures have focused on interface designs that relate to aspects like user-friendliness, ease of use and system efficiency. Usability criteria that relate to interface usability dimension are the ones highlighted by Nielsen (1993), which are among the most applied in studies of usability evaluation. The criteria are:

    - *Learnability*: Ease of learning such that a user can easily and quickly begin to use the system.

    - *Efficiency*: It concerns a user's ability in using the system with a high level of productivity.

    - *Memorability*: It relates to a user's capability to easily remember how to use the system even after not using it for a period of time.

    - *Error tolerant*: The digital library system should have a low error rate with fewer user errors and easy recovery from them.

    Overall, interface usability covers aspects of how users can learn to navigate or browse the system especially for information seeking and familiarity with functions that are reliable in providing the expected information (results) searched. It can be concluded that the interface usability dimension is the direct or explicit usability between users and the digital library where the usability criteria are directly connected to the system. However, the indirect or implicit usability is the institutional usability dimension, which is discussed next.

2. Institutional usability dimensions

This study regards this institutional usability dimension as implicit usability dimensions due to the fact that they do not directly represent the connections between the users and digital library system per se, but to their work environment. That is why Kling and Elliot (1994) argued that in the context of digital libraries, institutional (or

'organizational' as referred to by the researchers), usability is less well understood as compared to interface usability. They defined this type of institutional usability dimension as ways that computer systems can be effectively integrated into the work practices of specific organisations. They regarded "design for usability" as a term referring to the design of computer systems so that they could be effectively integrated into the work practices of specific organisations. They believed that it might encourage system designers either to accommodate to people's mixed skills, work practices, and resources or to try to systematically alter them.

The four main attributes in fitting digital libraries to organizations proposed by Kling and Elliot (1994) are as follows:

- *Accessibility*: The ease of users in locating specific computer systems, gain physical access and electronic access to their electronic corpuses.

- *Compatibility*: This refers to the compatibility level of file transfers from system to system.

- *Integrability*: This dimension considers the smoothness of the system fitting into a person or group's work practices.

- *Social-organizational expertise*: This relates to the extent to which people can obtain training and consulting to learn to use the systems and find help with problems in usage.

These dimensions (or attributes) which represent the digital libraries are more or less usable by people in supporting their work. While there are many critical issues relating to the design of a digital library architecture (Fullerton et al., 1999), as for academic institutions, the missions in building digital libraries should of course integrate and marry with the academic societies' information needs and expectations, as well as being in line with the institution's vision and mission.

In the context of academic digital libraries, both of these dimensions are relatively crucial in providing a digital library system that can fit and serve the academic purposes for its main target users, i.e., students, academicians and researchers. Academic resources ranging from journals to books are rapidly under the transformation phase to digital formats. It is in line with the claim made by Hugget and Rasmussen (2011) and Coyle (2006) that due to large-scale digitization projects, scholarly books are progressively converted into the digital formats. They are both potential elements in revealing issues related to usability and can be exposed to evaluating digital libraries via the usability evaluation approach. Blandford, Stelmaszewska and Bryan-Kinns (2001) conducted a research in work patterns with library resources and found a clear distinction between the acts of browsing and searching information sources. Based on the study by Goh et al. (2006), one of the key functionalities of a digital library is that they should match with users' work patterns. They emphasised that to achieve this, there should be a thorough understanding of the library users and the system itself. Apart from the need for a deeper understanding of the users, the fit between the tools used to shape the digital library and the necessary requirements have to be ascertained as well. Snead et al. (2005) earlier reported that it is possible to create a rich and robust evaluation methodology that can meet the needs of diverse user populations by combining functionality, usability, and accessibility.

Mohd Razilan, Fatimah and Diljit (2008) stated that many existing areas of research in digital libraries are being carried out to fulfill the demand in information retrieval, either from the user-perspective or system-perspective. To cater for users' information needs, although these two acts are at one point related to interface usability, they are also connected to the third organisational usability dimension, which is the integrity of the systems in ensuring a smooth browse and search system to support users' academic practices. This consideration falls back to the aspect of Information

Systems technology that provides the information retrieval mechanism. In addition, digital libraries are used as information providers to meet users' information needs. In fact, the first three dimensions in institutional usability are closely related to Information Systems technology, given that they need to be evaluated as part of the usability approach in evaluating academic digital libraries, as well as general digital libraries. Thus, it is imperative to value the significance of taking into consideration the combination of the supportiveness of system designs in work practices and user expectations as usability evaluation dimensions in evaluating digital libraries.

The aspects of systems design proposed here are not technical but based on the acceptability of the infrastructure of the digital library system (software and hardware) in supporting their contexts of usage. For example, medical students and researchers may need specific information that is different from mathematics students and researchers, as and so on. Therefore, institutional dimensions can be potentially used in reflecting and extracting these needs through usability studies.

From the study objective, another angle of the digital library that could be investigated is its impact based on the usability measures, that could be gained from usability techniques. The subsequent section presents the discussion on this research.

2.9.   Impact Studies on the Usage of Digital Libraries

Standard and universal benchmarks for measuring the impact of digital libraries have not yet appeared (Chowdhury, Landoni and Gibb, 2006). But recent studies have assessed the impact of digital libraries on specific groups of users and their activities, like Alexandria Digital Library Prototype and Perseus Digital Library, which tried to assess the uses and impacts of digital libraries on the activities of the target users.

Usability is the extent of how users easily and effectively use a product or system (Koohang, 2004). On the other hand, *usage* in the context of Information Systems is the use of a digital library. The latter construct is the focus of this study in

order to evaluate the success of digital library, one needs to characterise *how* and *for what* the digital library is used. Consequently, usage impact on digital libraries should be explored and investigated in understanding and determining the capability and features of digital library systems in satisfying users' needs.

Previous research showed that when attention turned to subjective cultural factors impacting digital library usability, emphasis was initially placed on global interface design principles and insights gained from the human-computer interaction (HCI) field (Smith, 2006). It was earlier suggested by Saracevic (2005) that the use of the usability-centered approach involves the assessment of different features, particularly with respect to portals, by users. It is a bridge between systems-centered and human-centered approaches. This directly means that a user interface plays an important role in determining the usability impact on users' interests and behaviour, within their scope of usage.

Research (Barber and Badre, 1998) has also shown that interface design elements appropriate for one culture, such as colours, icons and text orientation, may not be appreciated by users from other cultures. While Ferreira and Pithan (2005) later suggested that it is possible to observe users' actions, feelings and thoughts, as well as their experiences which disclose significant indications to learning components, memorisation, errors, efficiency of the digital library and mainly users' satisfaction. Smith (2006) also stated that the interface design, while important and fundamental to global usability, is clearly just one area impacting the effective design of cross-cultural digital libraries.

Some reviews on past studies conducted on models in assessing the digital library are briefly discussed in the following section.

2.10. Performance Indicators of Digital Library Systems

Previous research has shown that digital libraries' practical applications have outpaced the emergence of methods for evaluating them (Saracevic, 2000). This indicates that there was a lack of interest in the evaluation of digital libraries during the early period of digital library development. The initial period of digital library research paid relatively little attention to evaluation, but Chowdhury, Landoni and Gibb (2006) claimed that since early 2000 or so, a number of researchers have attempted to evaluate different aspects of digital libraries. Mittal and Mahesh (2008) outlined several types of evaluation research on digital libraries that were carried out. Firstly, the early phase focused on evaluating the technical aspects of building digital libraries; secondly, it shifted to the design aspects of digital libraries (in connection with evaluating users' satisfaction). Thirdly, the evaluation centred on examining the impact of digital libraries to users and their communities. Lastly, evaluation of digital libraries was also carried out on the collections, access methods, services or from the user's point of view. But according to Xie (2006), some digital library evaluation studies went beyond usability and examined the content and performance of the system.

Establishing evaluation requirements to determine the performance indicators of digital libraries would hardly be standardised because most of the evaluative work was tailored to the objectives and missions of the digital libraries developed. Bertot, McClure and William (2004) stated that evaluative approaches tended to be tailored to the particular needs of an organisation; linked to available time and funding; limited by the scope and breadth of application due to funding, planning and so on. Tsakonas, Kapidakis and Papatheodorou (2004) posed one possible suggestion to this issue, i.e., the development and participation to testbeds. Also, as pointed out by Saracevic and Covi (2000), the evaluation of digital libraries is a complex undertaking that is conceptually and pragmatically challenging. Xie (2006) stated that evaluations are

based on the conceptual model of the evaluators based on their understanding of the goals of the system and of users' needs and behaviours.

Toms (2000) claimed that to date, measuring the outcome from Information Systems has been done by assessing the extent of comprehension and learning, assessing the pertinence of the information to the user, gauging user's satisfaction, examining the number of nodes accessed by the user, calculating the time for various activities or evaluating user's navigational patterns. In the assessment of browsing experiences, Toms, Dufour and Hesemeier (2004) used both subjective metrics such as interest and objective metrics and exploration and novelty. Based on ISO 11620 (1998), the purpose of performance indicators is to assess the quality and effectiveness of services provided by a library, and to assess the efficiency of resources allocated by the library to such services.

Poll's (2001) study showed that performance indicators are meant to assess the goodness of library services, not only the quantitative data extracted like number of user workstations, the hours that the workstations are accessible per year, the amount of use for different services, and so forth.

As claimed by Chowdhury, Landoni and Gibb (2006), the digital library is a complex construct. He suggested that what is to be measured through an evaluation study, will depend on a number of factors. Factors like hardware, software and networking, data formats, access and transfer times, failure rates, development and maintenance costs should also be considered apart from content, information retrieval and usability. These measures are actually interconnected and users experience it by interacting with the digital library systems through the interface designed.

A research on digital libraries' key performance indicators based on ASK model (Attributes, Support and Knowledge) performed by Rigby and Smithers (2007) found that the performance indicators related to Support and Knowledge were adaptable to the

digital reference environment. However, attributes were considered subjective, open to interpretations, and therefore have questionable validity and reliability. Their research recommended that standardised collection forms, definitions of reference categories and data collection methodologies should be established for easier benchmarking of different digital library systems.

But interestingly, Tsakonas, Kapidakis and Papatheodorou (2004) contended that the main factors affecting user behavior are the system performance and content appropriateness to user needs. Therefore, to measure the performance of digital libraries is not based only on the system, rather it should also take into account user behaviour. Cherry and Duff (2002) conducted a longitudinal study of a digital library collection of Early Canadiana Materials, focusing on how the digital library was used and the level of user satisfaction with different features of the digital library, such as response time, browsing capabilities, comprehensiveness of the collection, print function, search capabilities, and display of document pages.

For the purpose of this study, the performance indicators of digital library systems will be analysed based on usability measure as a quality of use. There is a close analogy between different interpretations of the term usability and comparable interpretations of the term quality. Although the term quality seems self-explanatory in everyday usage, in practice there are many different views of what it means and how it should be achieved (Bevan, 1995). As emphasized by Bevan (1995), a traditional view of quality of use is, it is a simple unanalyzable property which is recognised through experience. The usability technique is selected due to this main reason: experience based on quality of use from the targeted users of academic digital library, i.e. from students, academicians and researchers. With respect to this, the academic digital library is a special system to provide and facilitate the needs of this target community in terms of academic-related information which largely serves as the core information required

by its community. Within this academic-related domain, we need to investigate how the system's usefulness can be gauged in the sense of how usable the system is serving its intended role in the academic community.

In the following section, some important considerations on the digital library performance are discussed.

2.11. Review of Conceptual Models and Techniques in Evaluating Digital Libraries

Bertot, McClure and William (2004) once claimed that there were no standard definitions or approaches to library evaluation approaches, strategies, or practices. The evaluation approach for this study is conducted based on users' perspectives in investigating and understanding their interactions with academic digital libraries, and how the digital library can meet their needs in the academic environment.

2.11.1. Conceptual Model Developed by DELOS

The initial conceptual model for the evaluation of the digital library was discussed in the first DELOS evaluation workshop held in Budapest in 2002. Their working group developed a generic definition of a digital library model as shown in Figure 2.5. It comprises three main components: users, the data/collection (content) and technology. In this model, the two thick arrows for **user** (**content** and **content➔technology** indicate that a group of users *predetermines* the relevant content and the type of content *predetermines* the relevant technology to be used, respectively. The thin arrows (➔) indicate the HCI, whilst the dotted arrows (⤳) demonstrate that the observed overall digital library usage is dependent on the collective contribution of users, content and technology.
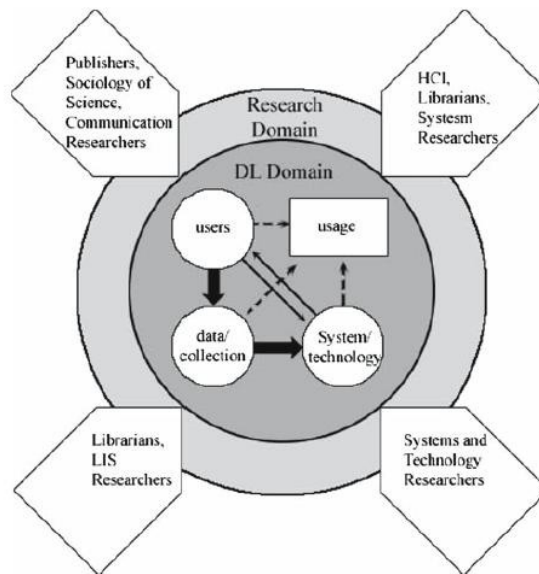
Figure 2.5: Framework of the initial version of digital library conceptual evaluation model

Source: Fuhr et al. (2007)

While this is captured in the digital library domain, this model can be extended to potential principal research domains such as users, usage, collection and technology. The aim is to create evaluation criteria (based on the three components in the digital library domain) and the evaluation metrics will be based on these criteria, based on the requirements of the researcher.

2.11.2. Interaction Triptych Model

Tsakonas, Kapidakis and Papatheodorou (2004) emphasized that the digital library interaction evaluation is aimed for users' benefit and focused mainly on analyzing their behaviour when they interact with a digital library. He stressed again that the critical factors affecting users' behaviour are the system performance and the relevancy of content to the users' needs. Since the notion of usability is said to be insufficient to cover those aspects, the evaluation model thus requires a relationship between these components: *user-system*, *content-system* and *user-content*. This is depicted in the

interaction triptych model (Figure 2.6) developed by Tsakonas, Kapidakis and Papatheodorou (2004).
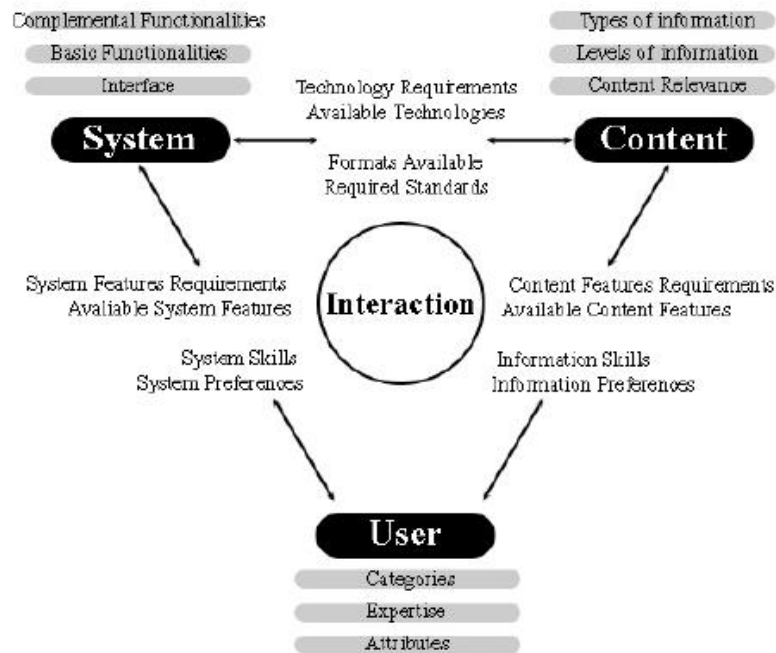

Figure 2.6: Framework of the digital library evaluation approach based on the interaction triptych model

Source: Tsakonas, Kapidakis and Papatheodorou (2004)

The digital library evaluation framework in Figure 2.6 shows three main interaction components and their relationships, as mentioned earlier. Thus this model represents the interactions between the components of a digital library via a set of properties expressed during the interaction processes. Thus, based on the requirements of the interaction triangle, appropriate methods for evaluating the interaction should be considered. For this study, in aiming at investigating users' usability aspects with the academic digital library system and content, a questionnaire (via survey) was seen as a potential method in collecting users' opinions and views.

2.11.3. Usability Evaluation

Jeng (2005) summarised usability assessment for academic digital libraries, by various authors, according to their methods, subjects (respondents), areas and criteria, as

illustrated in Table 2.2 (more detailed descriptions and discussions are available in the author's doctoral dissertation):

Table 2.2: Usability assessments' previous studies.

Site	Methods	Subjects	Areas	Criteria	Authors
ACM, IEEE-CS NCSTRL, NDLTD	formal usability test questionnaire	48 students (38 graduate, 10 undergraduate)	interface	ease of use	Kengeri et al. (1999)
ACMDL, NCSTRL NZDL	questionnaire heuristic evaluation	45 undergraduate	design and structure	satisfaction	Theng et al. (2000a, 2000b)
Alexandria	questionnaire formal usability test	23 students	interface		Thomas (1998)
Belgian-American Research Collection	focus group formal usability test questionnaire	7 graduate students in focus group, 5 users in usability test	design navigation	satisfaction	Clark (2004)
CUNY+	questionnaire	10 students	interface	affect, efficiency, control, helpfulness, adaptability	Oulanov & Pajarillo (2002)
DeLIver	transaction log survey, interview focus groups, formal usability test	1900 graduate 420 faculty	accessibility		Neumann & Bishop (1998) Bishop (2001)
DLESE, NSDL	focus groups	36 teachers 2 librarians	design		Sumner et al. (2003)
Florida International U.	formal usability test questionnaire	52 subjects	design, organization, navigation, vocabulary	efficiency satisfaction	Hammill (2003)
Getty Research Institute	formal usability test log analysis	4 current users 4 potential users	navigation		Hessel, Burton-West(2003)
Instructional Architect	formal usability test focus group	26 teachers	interface, content		Dorward et al. (2002)
London Hospital	focus groups Interviews	73 clinicians	accessibility		Adams & Blandford (2002)
MARIAN (Virginia Tech)	formal usability test log analysis questionnaire	students, faculty, staff	interface		France et al. (1999)
MIT	formal usability test	29 (faculty, graduate, undergraduate, staff)	site design		Hennig (1999)
National Taiwan U.	questionnaire	1784 faculty and students	information architecture browsing & searching mechanism layout and display	satisfaction	Lan (2001)
NCSTRL	usability inspection	3 usability experts	design, interface, functionality		Hartson et al. (2004)
SABIO	formal usability test heuristic evaluation design walk-through card sorting	students	design		Dickstein & Mills (2000)
U. of Illinois at Chicago	formal usability test	12 students	navigation	effectiveness efficiency	Augustine & Greene (2002)
U. of South Florida	formal usability test	26 undergraduate	interface		Allen (2002)
U. of Southern California	formal usability test	1) 5 faculty, 1 staff, 1 student 2) 2 faculty, 4 staff	architecture, terminology, color, navigation	effectiveness	Benjes & Brown (2001)
U. of the Pacific	formal usability test	134 students	awareness of library resources	Krueger et al. (2004)	
Washington State U.	formal usability test questionnaire	12 students	navigation		Chisman et al. (1999) Walbridge (2000)

Source: Jeng (2005)

While Bertot et al. (2006) presented a combination of methodologies to evaluate and measure the performance of library websites, the information they contain, and the services they deliver are against set standards. They referred to Ryan, McClure and Bertot (2001) and Thompson, McClure and Jaeger (2003); where *evaluation* can play both a formative role, helping to continually refine and update goals, objectives, and services; and a summative role, helping to ascertain whether the goals and objectives are being met.

Rather than focus strictly on technological aspects, Bertot et al. (2006) combined functionality, usability, and accessibility aspects where they used methodologies that provided different data regarding the ability of a digital library to meet the needs of users. In specific terms:

- Functionality testing determines the extent to which a digital library, in whole or in part, is able to perform desired operations (e.g., basic search, multiple languages).

- Usability testing determines the extent to which a digital library, in whole or in part, enables users to intuitively use a digital library's various features.

- Accessibility testing determines the extent to which a digital library, in whole or in part, provides users with the ability to interact with the digital library.

Table 2.3 presents some previous works by different authors in library science research with regard to evaluating digital libraries via each of these methods.

Table 2.3: Evaluating digital libraries from the aspects of functionality, usability and accessibility; based on the respective purposes of the studies and the related authors

Method	Purposes	Selected resources
Functionality	• Assesses whether the digital library (or component) actually works in the manner it is intended and provides the results it is meant to deliver • Can be used to make comparisons between separate, comparable programs with similar goals	Bertot, 2002; Bertot et al., 2003; Wallace, 2001
Usability	• Assesses how users react to and interact with the program • Can allow the user to express personal impressions of the resource, such as satisfaction, • utility, value, helpfulness, benefits, frustration, and self-efficacy	Dalrymple and Zweizig, 1992; Hert, 2001; Sweeney et al., 1993
Accessibility	• Assesses how well systems allow users with disabilities to have equal or equivalent use of information and services. • Measures often tied to the suggested accessibility guidelines of the World Wide Web Consortium or the guidelines of Section 508 of the Rehabilitation Act (29 U.S.C. § 794d)[1]	Jaeger, 2002; Nadler and Furman, 2001; Section 508, n. d.; World Wide Web Consortium, 1998[1]

Source: Bertot et al. (2006)

In an attempt to evaluate the performance of digital libraries, several evaluation techniques have been discussed in the literature. The most widely applied are usability evaluation and the literature shows various types of evaluation methods applied in usability studies. Among them are Nielsen (1993), Blandford, Buchanan and Jones (2004), Jeng (2005), and Reeves, Apedoe and Woo (2005), and the types are:

1. **Survey**: questionnaires distributed to targeted respondents in obtaining preliminary feedback on the usability of the digital libraries to reveal the current patterns of use, and usability issues with respect to the digital library uses. Tsakonas, Kapidakis and Papatheodorou (2004) agreed that online questionnaires and surveys are the most commonly used subjective methods for the collection of data, especially in the case of remote users and a large sample population.

2. **Observations**: a structured observation where the behaviour of a sample of individuals using digital library is observed.

3. **Usability testing**: formal laboratory settings of testing how digital library interfaces support users in completing their tasks.

4. **Transaction log analysis**: user statistics captured by the digital library's log system.

5. **Focus group**: digital libraries' usability information collected from a group of people who have experience in using them.

6. **Heuristic evaluation**: a small set of expert evaluators to determine whether a system conforms to a set of usability principles known as heuristics, and identify specific usability problems in the system.

However, Reeves, Apedoe and Woo (2005) categorised usability evaluation methods into three categories to guide evaluation tasks. The categories are:

i). *Inspection*: This category consists of heuristic evaluation and cognitive walk-through models. This method requires experts to systematically review the usability of a digital library and recommend improvements.

ii). *Testing*: This is an evaluative process whereby human-computer interactions are systematically tested and enhanced (from the use of digital library interfaces).

iii). *Inquiry*: This category resembles usability testing but the difference is the evaluators observe users using the digital library in real settings.

The type of evaluation model to use rather depends on the objective of the evaluation itself, the nature of the digital library, target users and its contents. Usability studies conducted by Kassim and Kochtanek (2003) on academic digital libraries were performed through the use of a mix of usability models: focus groups, Web log analysis, database usage analysis, satisfaction surveys and remote usability testing. Their studies

attempted to understand user needs, find problems and desired features, and assess overall user satisfaction. Another method in evaluating digital libraries was done by Borgman et al. (2000) where they evaluated the Alexandria Digital Earth Prototype for use in undergraduate education, by using surveys, interviews, and classroom observations.

2.11.4. Information Retrieval Evaluation

Two main types of information retrieval (IR) evaluation is commonly applied in digital library evaluations, as follows (Saracevic, 1995; Jaana and Kalervo, 2005):

i). User-oriented: evaluation is based on users' experiences with the information retrieval perspectives that are related to the digital library system. This depends on how experienced they are in using the digital library to meet their needs or interests.

ii). System-oriented: evaluation is based on how the retrieval system of the digital library is performed with respect to users' needs and interests.

This study is a user-centered study; thus with respect to the Information Systems point of view, information retrieval evaluation is performed via the user-oriented approach. The scope of information retrieval evaluation is based on the users' experience of interacting with digital libraries (user-system relation), as discussed in digital library usage for information provisioning dimensions.

2.12. Analysing Digital Libraries Performance

Digital libraries are public Information Systems that can be analysed from several perspectives as regards to users and usages, data contents, technical and organizational aspects. Information Systems always include people and information, but they may also include man-made artifacts such as computers, data, and computer-supported data

processing systems, supporting and amplifying the human mind in mental operations (Sundgren and Steneskog, 2003).

Digital libraries are Information Systems which consists of complex systems and evaluating complex systems is not that easy. The proliferation of Information Systems (including databases, digital libraries, websites, among others) shows the difficulty designers are faced with in the attempt to catch and to satisfy users' expectations and interests (Ferreira and Pithan, 2005). With the diversity in digital library development projects today, it brings multiple perspectives and factors on how one can actually evaluate the libraries' performance, either from the users' perspective or system perspective. In other words, many researchers and digital library teams are still in the experimental stages of evaluating the performance of digital libraries, and have yet to set solid-and-standard performance indicators as the criteria for evaluation. However, Saracevic (2000) briefly stated the problem of the design, development, evaluation and interaction of digital libraries, as follows:

> *So far, evaluation has not kept pace with efforts in digital libraries (or digital libraries themselves), has not become a part of their integral activity, and has not been even specified as to what it means and how to do it.*

As for physical libraries, performance indicators set by ISO (International Standard of Organization), i.e., ISO 11620: 2006 was the second edition that cancels and replaces the first edition (ISO 11620: 1998 (E)), Amendment 1 (ISO 11620: 2003 Amendment 1 (E), and Technical Report 20983 (ISO/TR 20983: 2003 (E)). The revision incorporates performance indicators for electronic and traditional library services and resources into a single document, and includes technical updates to indicators of electronic and traditional library services and resources (ISO, 2006). Even when the performance measurements are available (like resources, access and infrastructure), they do have limitations. As mentioned in ISO 11620, not all indicators

are applicable to all libraries, but they can be used with caution and for the purpose of making comparisons over time within the same libraries. A recent study by Teoh and Tan (2011) investigated the determinants of physical library usage among Malaysian students by using demographic and socioeconomic factors. Their findings indicated among the tested determinants, ethnicity, year of study, frequent online users and students exposed to library induction courses were the significant determinants. While a student's gender, parents' educational background, place of living, course taken and working status were not significant.

But since research is a never ending process, the past few years have witnessed the works of Saracevic (2000, 2004), Nicholson (2004), and Reeves, Apedoe and Woo (2005) on topics like overview, issues and guidelines on evaluating digital libraries. Saracevic (2004) claimed that an effective evaluation should consist of the context in which it is evaluated, the performance criteria, measures, and methodologies. The context is either user-centered (between user and system) or system-centered (system performance-wise).

Apart from discussing assessment and evaluating digital library, Nicholson (2004) touched on the advantages of digital library evaluation over traditional (physical) library evaluation. The most outstanding advantage is the large collection of data that a digital library has like *bibliomining*, data warehousing and data mining (that can be tracked by the digital library system) and so forth, can serve as data for studying the usage pattern of that particular digital library.

Reeves, Apedoe and Woo (2005) discussed the guidelines on evaluating digital libraries by outlining several criteria that can be taken into account such as usability, service, information retrieval and *bibliometrics*. A bibliometrics approach is designated to investigate the influence of a particular researcher's work within a field of study by

determining how frequently the researcher is cited and the pattern of those citations (Reeves, Apedoe and Woo, 2005).

Evaluation methods for usability assessment of academic digital libraries were carried out by Jeng (2005) where she discussed the methods that have been applied in evaluating usability of digital libraries, their applicability, and criteria. Jeng's study revealed that an interlocking relationship exists among effectiveness, efficiency, and satisfaction. The relationship was studied in terms of the statistical correlations between the selected parameters analysed.

> *Broadly conceived, the modern academic library system is a repository of such clues as to the workings of our world and its contents. Such a purpose is noble and to some extent, immune from shifts in technology, though one must accept both the threats and opportunities that such shifts might enable* (Dillon, 2007).

As asserted by Dillon (2007), the explosion in digital resources reflects the rapid embracing of new tools and techniques for knowledge production that have not followed the predicted paths. He cautioned two major concerns in dealing with digital tools and collections are security and economy. The makeover of academic library for the 21st century can be achieved by merging the skills and knowledge from both academic libraries and academic computing. Wilson (2012) highlighted the approaches taken by institutions that potential of transforming the research and learning ways and reducing costs, by creating comprehensive digital libraries. As an example, Orbis Cascade Alliance in the United States constitutes of over 30 academic libraries in the Pacific Northwest, which have leveraged the cost of borrowing and lending and as well as expedited resource sharing. Without a doubt, digital libraries have become a fundamental information source for academicians, researchers, and students in research and education (Joo and Lee, 2011).

Performance evaluation of information retrieval in the context of digital library evaluation is defined as finding the information (e.g., a text document, a media object,

or a fact) that a user is seeking (Reeves, Apedoe and Woo, 2005). Information retrieval evaluation is not about evaluating the technical functionality of the information retrieval system, but also focusing on issues such as the utility of metadata.

2.12.1. Some Considerations of Analysis

It is well understood that digital libraries evolved from inter-disciplines of library and information sciences, human-computer interaction, and also computer science. According to Choi and Rasmussen (2006), digital libraries have unique characteristics which made them different from traditional libraries and their procedures for information provisioning. The criteria of these fields can be used to analyse the digital libraries' performance. In the aspect of information retrieval systems, digital libraries can be assessed using measures of relevance and satisfaction. The criteria for studies of human-computer interaction and interface design, such as usability, task appropriateness, design features, navigation, and browsing, are some of the most commonly applied measures (Saracevic, 2000). Information retrieval evaluation deals with two categories, user-oriented and systems-oriented. From the user perspective, information retrieval evaluation is appropriately focused on evaluating how effectively and efficiently a user's search for information meets his or her needs or interests. From the systems perspective, information retrieval evaluation is focused on evaluating the effectiveness and efficiency of the retrieval system that is at the core of any digital libraries.

Widely used methodologies for evaluation are by considering usability, surveys and also transaction log analysis. In Xie's (2006) survey study of users' criteria for digital library evaluation, he grouped five types of evaluation criteria: usability, collection quality, service quality, system performance efficiency and user opinion solicitation; based on answers given by his respondents. But caution has to be made

especially in designing the questionnaires for the surveys. Drawbacks about surveys are likely on how honest the respondents responded to the given questions, the outcomes probably cannot be inferred to the population, and highly dependent on the design of the questionnaire. Transaction log analysis may be useful in revealing and/or monitoring trends of the use of digital library systems, like tracking the number of sessions or by IP addresses. As explained by Reeves, Apedoe and Woo (2005), transaction log analysis is to understand how users navigate through particular digital libraries, which resources they access, and any such problems they encounter.

In a different evaluation perspective, Cabrerizo et al. (2010) proposed a fuzzy model to evaluate the quality of digital libraries by using fuzzy linguistic information from user perceptions. The fuzzy model generates subjective criteria (recommendations) from the users in order to improve the digital services and functionality of the academic DLs. Its main objective was for both assessing the quality of each subjective criterion proposed and the global quality on the DL.

A study to identify different types of help-seeking situations that lead users to look for help in digital libraries are taken by Xie and Cool (2009). Still, to some extent, they concluded that the overall interface design is the best help for the information retrieval system such as digital libraries.

Digital libraries are Information Systems developed with specific purposes to fit their target communities. As regards Internet and Intranet infrastructure, digital libraries for academics are not an exception to the evaluation. Academic digital library development may not comprise a standard development cycle as they are considered more customised to institutional requirements, information needs, budget and infrastructure. Academic digital libraries are online library resources for students, academicians/researchers gain resources and services related to academic by accessing public and private databases through application software, internets and intranets. The

general intention of individuals (from this academic community) using digital libraries is to gain intellectual knowledge from digitised and online materials provided by the resources and services available in the digital library system. Digital libraries and institutional repositories populate the networked research materials related to scholarly activities like research, teaching, research works such as theses and dissertations, conference papers and journal articles (Maizatul and Sameem, 2011).

In relation to this, the success of the digital library systems may not be sufficient to be assessed by looking at one angle – the system. Another important angle is linking the system with individuals' behaviour, their performance and needs of using functions, features, contents and service of digital libraries. The foci of investigating this linkage are that it will provide an understanding the usefulness of the digital library in supporting the community's (students and academicians) own context of use. In the event that the Information System fails to meet users' needs, the latter will search for alternatives or the Information System may not be usable or beneficial to this academic community. In practice, one should be content that the evaluation results using Information Systems models cannot be duly regarded as a total solution in measuring the performance of Information Systems. Although it is not comprehensive, the outcomes are advantageous either to understand the efficacy of the system or as a benchmark.

The research in assessing Information Systems has been carried out for almost thirty years and is still ongoing. However, research on digital libraries has been going on for about a decade. Until recent years, applications of IS Success measures are still scarce in library science research. Thus this study sought to investigate the success of digital libraries grounded by IS Success theory. To gauge the performance of particular digital libraries, evaluative study is one of the possible ways. This research will study and analyse the performance of Information Systems in digital libraries from the users'

perspective, based on the IS Success model. This study extends the literature by investigating the: (1) level of user awareness and its relationship with the individual usage impact, (2) individual usage of digital libraries for information provisioning, (3) impact of digital library usage for information provisioning, (4) usage of digital library systems as Information Systems' success, and 5) performance indicators based on the success of the digital library.

2.12.2. Awareness in Digital Libraries Assessment

In this study, user awareness of digital libraries refers to their awareness of digital libraries as Information Systems, as well as their services and functionalities. Digital library systems involve a range of information access systems and processing activities, and depends on users and their usages. As Information Systems, digital libraries involve information handling processes designed to serve users until they have accessed and retrieved the needed information. In other words, digital libraries perform tasks as do other Information Systems. Even though awareness in human-computer-interaction has been studied (Dourish and Bellotti, 1992), not much has been done in the context of digital libraries (Hansen and Järvelin, 2005). Only recently, some initiatives in studying the awareness of digital libraries have been done by some universities. For example, a survey study by University of Rhode Island (2006) found that levels of awareness and experience with digital libraries are still low. However, their respondents did recognize the benefits of centralised systems like Digital Libraries. Another survey was done by Asemi and Riyahiniya (2007), investigating the relationships between awareness and use of digital resources among students in Isfahan University of Medical Sciences. Their findings showed that 70% of the students were aware of digital resources and 62% of offline databases. However, only about 19% used them through the university's Central Library LAN network.

Since research on awareness in the context of digital libraries is scarce, as reflected in the review of the literature (Farooq et al., 2008), it is important to explore the awareness of digital libraries among academic-related users. Since awareness is related to the ability to know and ability to understand from the environment where one fits in, this factor may provide the insight on how digital libraries are actually being used, benefitted and appreciated in users' information-seeking processes with respect to academic purposes. Thus, the awareness covers the aspects of awareness of objects (digital library functionalities), awareness of activities (digital library services) and awareness of people (sharing and communicating with colleagues).

2.12.3. Usage of Digital Libraries for Information Provisioning

In Information Systems research, *usage* can be conceptualized as *use of a system* (Rai, Lang and Welker, 2002; Barki and Hartwick, 1989) and *use of information from the system* (Szajna, 1993; Barkin and Dickson, 1977). However, this study focuses on investigating the use of a system (digital libraries) for academic reasons. The use of digital libraries for information provisioning is critical to be investigated because via the pattern of use, it may reveal *how* and *for what* the digital library system is used. The pattern of use is not only based on the usage of digital libraries but consists of usage constructs as recommended by Ambrose, Rai and Ramaprasad (2006) viz. breadth of content, depth of content and interaction dynamism.

In digital libraries' perspectives, the use may reflect the usability of the system. The International Standards Organization (1994) defines usability as "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use." Blandford and Buchanan (2003) asserted that there is no consensus on what the key criteria are for evaluating the usability of digital libraries. This is supported by Jeng (2005) who believed that usability is an elusive concept and is determined by the tasks, the users,

the product, and the environment. In the literature the term "usability" has been used broadly and means different things to different people. As discussed earlier, this research, however, will focus on the *use of digital libraries* and the system is treated as a means to provide users with information at all levels as needed. The aspect of usability, on the other hand, will be incorporated as part of the tested measures in the study *a-priori* model for the IS Success.

Based on limited previous studies analysed, Bawden and Vilar (2006) believed that there is evidence that expectations differ between different types of users of digital libraries. They referred to Hill et al.'s (1997) study where the University of California established users' expectation differences between earth scientists, information specialists, and educators. The earth scientists, for example, expect tight links between the library resources and their local data manipulation environment, while the educators expected content and functionality in direct support of educational goals.

Although a particular digital library may not possibly fulfill all types of user needs, at least having the knowledge of their requirements is worthwhile in making the digital libraries' implementation a success. This is because the impact of usability of digital libraries would also determine the survival of digital libraries in the long run. In simpler words, the lifecycle of a particular digital library should take into account how its users find it useful to them; otherwise, they may not show preference in using the resource.

2.12.4. Usage of Digital Libraries Systems as Information Systems Success

With different types of users and needs, it is not easy to fulfill digital libraries' needs simultaneously but it is worth to know the service impact on their unique target users. In the Information Systems literature, the usage of systems has led to different meanings that brought different paradigms of research: IS for Decision-making, IS

Implementation, IS Acceptance and IS Success. The aforementioned definition of *usage* as *use of a digital library* in the previous subsection specifies *how* and *for what* the digital libraries are used for information provisioning. In addition, this subsection further elaborates the focus of the study, i.e., to analyze the performance of the digital libraries where the scope of Information Systems research paradigm is the IS Success.

IS Success can be treated as an event in a process leading to individual impact and organizational impact (Sedera & Tan, 2007; Burton-Jones and Straub, 2006; Seddon, 1997). Thus the usage of digital libraries is worth investigating, such as how the system is beneficial to individuals as well as institutions. This is called the *impact* or *net benefits* received by users (individual and institutions), as elaborated in DeLone and McLean model developed in 1992, later updated in 2003 and 2004 (refer to Chapter Three). Their D&M IS Success model is the most cited and tested model in evaluating the success of Information Systems in Information Systems research (Sedera and Tan, 2007; Ambrose, Rai and Ramaprasad, 2006; Heo and Han, 2003; Myers, Kappelman and Prybutok, 1998). The IS Success (in this context, the DLs Success) is embarked to obtain a better understanding of how useful the systems are in aiding users' study and research works.

The main dimension tested for DLs usage as IS Success model constitutes four main dimensions: individual impact, institutional impact, system quality, and information quality. The first two dimensions are impacts to date where the other two are impacts anticipated (based on users' perceptions). The impacts include measures on how DLs have influenced the performance of users, how users perceive the goodness of outputs provided by the DLs and how users perceive how well the DLs have performed (in design and technically). The key proximate determinants for this IS Success model are drawn from the Information Systems literature (D&M IS Success and IS-Impact models).

2.12.5. Impact of Digital Libraries' Usage on Information Provisioning

Since little consensus has been reached on the dimensions and measures of IS Success, this study highlights the importance of conceptualising the *usage of digital libraries.* The digital library system is a repository system that can reach every user. Academically, digital libraries are knowledge repositories used to provide information at any level required by the academic users. The key point here is to provide information to academic users with different contexts of usage. Different contexts of usage reflect different users with different study backgrounds, and this leads to different uses. The information needs of social science students and academicians may differ from that of medical students and academicians, for instance. Different levels of information, the breadth and the depth of it, may differ between engineering students and academicians, and library science students and academicians. In meeting these different information requirements, there is still a lack of evidence of the impact of digital libraries' usage for the provision of information as required for academic purposes.

2.12.6. Performance Indicators for IS Success

Digital libraries are developed with the aim of being used by its target users. However, the study has shown that, despite the fast development of the digital library technology, its performance is sometimes overlooked. Gazan (2005) admitted that in practice, designers of digital libraries are more concerned with the present and future digital library projects than having ongoing evaluations of past digital library systems. Using digital libraries will indirectly create a relationship between users and digital library systems, users and digital libraries' contents, and system and contents. Therefore, analysing the digital libraries' performances based on users' perspective should

incorporate these interconnecting relationships so that it can produce a holistic performance of a particular digital library, when users' opinions are taken into account.

This study analyzed the overall performance of digital libraries based on the Information Systems' perspective and thus, the success of a digital library was modeled according to the IS Success model, which is based on a theoretical foundation. The rationale of using such a model is based on the arguments gathered from the literature. Understanding the impact of Information Systems to the individual has been a challenge to Information Systems researchers and practitioners (Sun, 2010). Furthermore, empirical IS Success measures from early studies were merely based on sound theory (Gable, Sedera and Chan, 2008; Torkzadeh and Doll, 1999). Due to lack (or weak point) of theoretical foundation in measuring IS Successes, many authors have raised their concerns on several issues. For example, Burton-Jones and Straub (2006) noted that inadequate conceptualisation and excessive dependence measurements may raise problems; DeLone and McLean (2003) were concerned about the inconsistency of the results of measurement model; and Ambrose, Rai and Ramaprasad (2006) argued that the use of Information Systems has not been adequately conceptualised, defined and operationalised. Based on the theory-based grounding of IS Impact (Gable, Sedera and Chan, 2008) and Information Systems Usage as Information Provisioning, IUIP (Ambrose, Rai and Ramaprasad, 2006), this study sets its directional focus on assessing the online library resources (a.k.a. digital library) using the revised and extended model of IS Impact. Performance or success indicators covering the four main constructs in the IS Impact model are individual impact, institutional impact, information impact and system impact. Additionally, the individual impact construct in the IS Impact model is reconciled with IUIP (in the study, it is called DLUIP) in order to conceptualise individual usage for self benefit (academically), and not for the organisation as defined by Gable, Sedera and Chan (2008). As emphasized by Kusunoki and Khoo (2012),

instruments (indicators) used for evaluation of digital libraries can be improved by customizing the terminology, descriptions, and scenarios used for a specific user group. Further, the study used the formative measurement model that was validated in the literature as formative measures and constructs (Gable, Sedera and Chan, 2008; Ambrose, Rai and Ramaprasad, 2006).

The inception of formative models was said to be about more than four decades back, but the methodological discussion in the literature emerged only in the 1990s. Previous studies indicated that most social science researchers assumed effect indicators (reflective) which contributed to the lack of empirical studies on the formative model (causal indicators). Studies by Gable and Sedera (2009) and Petter, Straub and Rai (2007) highlighted the issue of validating constructs in Information Systems research for the past 30 years as reflective but were implicitly operationalised as formative. Gable and Sedera (2009) studied 43 empirical papers on IS Success gathered from nine top ranking journals; (1) *MIS Quarterly*, (2) *Information Systems Research*, (3) *Management Science*, (4) *Journal of MIS*, (5) *Journal of the AIS*, (6) *Decision Sciences*, (7) *Information and Management*, (8) *European Journal of Information Systems*, and (9) *International Conference on Information Systems*. They discovered that none of the studies used formative validation tests despite the fact that the measures were conceived as formative. The summary of the validity tests conducted by the 43 studies is provided in Table 2.4.

Table 2.4: Summary of the Information Systems construct validity tests conducted in 43 empirical studies in top ranking IS Journals

	Authors	Validity test
1.	Barki and Huff (1985)	Correlation, C.Alpha
2.	Bradley et al. (2006)	C.Alpha, AVE
3.	Brown, Gatian & Hicks (1995), Yuthas and Young (1998)	Correlation, T-test
4.	Doll, Xia & Torkzadeh (1994)	CFA, GFI
5.	Essex, Magal & Masteller (1998), Santhanam et al. (2000), Wixom & Watson (2001)	EFA, Correlation
6.	Gable et al. (2003)	EFA, C.Alpha, DC
7.	Gatian (1994)	RMSR, GFI

Table 2.4, continued

8.	Gelderman (1998)	C.Alpha, Correlation
9.	Goodhue (1998)	DC, CFA, C.Alpha
10.	Guimaraes (1997)	C.Alpha, DC, Correlation
11.	Guimaraes et al. (1992)	EFA, Variance analysis, R^2
12.	Hartono et al. (2007)	Pearson's R
13.	Kositanurit et al. (2006)	EFA, R^2
14.	Law & Gorla (1996), Bajwa, Rai & Brennen (1997), Rai et al. (2002), Sabherwal et al. (2006)	SEM
15.	Li (1997)	Chi-square
16.	Liu & Arnett (2000)	EFA,T-test
17.	Mahmood & Medewitz (1985)	Variance analysis
18.	McGill & Klobas (2005)	C.Alpha, GFI
19.	McHaney & Cronan (1998)	EFA, Correlation, GFI, C.Alpha
20.	McKinney et al. (2002)	AVE
21.	Miller & Doyle (1987)	EFA, Variance analysis, DC
22.	Mirani & Lederer (1998)	GFI, CFA, Correlation
23.	Nicolaou & McKnight (2006)	C.Alpha, AVE, EFA, PLS
24.	Rainer & Watson (1995)	EFA, Correlation, C.Alpha
25.	Raymond (1985, 1987)	EFA
26.	Sanders & Courtney (1985)	C.Alpha, Regression, F-test, Correlation
27.	Sedera & Gable (2004)	CFA, C.Alpha
28.	Sethi & King (1994)	Variance analysis, GFI, EFA
29.	Srinivasan (1985), Raymond (1990), Stylianou et al. (1996), Saarinen (1996), Lu & Wang (1997)	Correlation
30.	Tait and Vessey (1988)	C.Alpha
31.	Wixom & Todd (2005)	EFA, AVE, Correlation, PLS
32.	Wixom & Watson (2001)	EFA, C.Alpha

Source: Gable and Sedera (2009)
Note: C.Alpha= Cronbach Alpha, EFA= Exploratory Factor Analysis, CFA= Confirmatory Factor Analysis, DC= Discriminant Analysis, SEM= Structural Equation Model, PLS= Partial Least Squares, GFI= Goodness of Fit (in SEM), AVE= Average Variance Extracted

As scrutinised by Gable and Sedera (2009 : pp.7), all of the empirical studies did not validate their indicators using appropriate validity tests. This was due to reason that the constructs were treated as reflective instead of formative. Hence achieving parsimonious model and avoiding multicollinearity are overlooked in the validity technique employed. Moreover, the implications on the authors were considered unclear and beyond the scope of the study.

The IS-Impact model was developed with formative measures and construct, and validated with formative tests. The robustness and simplicity of the model, according to Elias and Cao (2009), is generalisable and capable of producing comparable results across time, stakeholders, different types of systems and system contexts. Gable, Sedera

and Chan (2008) and Gable and Sedera (2009) suggested that all of the four success constructs should be composed of formative indicators because the constructs are mutually exclusive and additive in nature. Hence, a combination (summation) of the indicators yields an overarching measure of success.

Performance indicators of digital libraries are important not only to gauge the functionalities provided (by the digital libraries), but over time, they can be used as guides to know how useful, how efficient, and how effective digital libraries are in providing their services on a long term basis. From this knowledge, future plans can be strategised so that digital libraries can benefit their target users and not only remain as unappreciated digital library systems. According to Barton (2004) and Mundt (2004), work has been done in the area of electronic resources, however, little has been done in developing performance indicators for the different forms of digital reference.

The study encompasses research related to digital libraries for academic purposes and the main actors are students, academicians and researchers. In consequence, the following section discusses the research variables used in assessing the success of digital libraries.

2.13. Research Variables

Having reviewed the past research, the proposed research is faced with all of the measures, indicators and constructs (for both the independent and dependent variables) that were posited in the literature. In the context of digital libraries, the work that is mostly related to this study is by Gable, Sedera and Chan (2008) and Ambrose, Rai and Ramaprasad (2006). The former authors introduced a comprehensive and validated measurement model that is suitable in measuring contemporary Information Systems like digital libraries, while the latter authors have developed an Information Systems usage metrics for knowledge-intensive purposes in the clinical domain. All of the research variables and designs are explained further in chapter 3. The constructs

(dimensions) of the proposed DL Success model are Individual usage impact, Institutional impact, Information quality and System quality (Gable, Sedera and Chan, 2008). While the dimensions postulated under the individual usage impact (IUI) are breadth of content, depth of content and interaction dynamism (Ambrose, Rai and Ramaprasad, 2006). All of these variables are investigated through the experiences of using such system among higher institution students. Considerations for developing a good digital library should take into account the system's service quality, system performance efficiency and feedback from users (Fazil, Abdullah and Noah, 2010). Beyond that, Xie (2006) asserted usability and collection quality as the two most important criteria for digital library evaluation.

2.14. Summary

Digital library systems like Information Systems can be analysed and evaluated from different perspectives and opened for research on a wide range of topics, such as user-centered design, usability, effectiveness, efficiency, governance, quality, security, and so forth.

However, it seems that digital libraries' evaluation efforts are hindered by a lack of tools and methodologies to reach a mutual benchmark. While most assessments of digital libraries take the usability aspect and users' experience with digital libraries, the outcomes are most valuable in guiding digital library's developers to continue developing digital libraries that comply with target users' needs within their context of usage. Technological advancements should also be taken into consideration to continue enhancing and improving digital library systems. It is mainly because digital libraries provide services to the public (people, universities, and companies/organisations). Therefore, they can support people and organizations to exercise and perform their tasks in line with current technology in Information Systems. Moreover, as online academic repositories, digital libraries are systems that provide information to users with different

contexts of usage. This is highlighted by the importance of the concept of digital library usage, that is how and for what the digital libraries are used by the target users.

Tsakonas and Papatheodorou (2011) admitted that while more than 15 years of intense research to fortify the domain of digital libraries, these systems continue to be challenging in terms of the assessment modeling. Moreover, while there is no standard way of analysing the performance of digital libraries, this research however will consider aspects and factors that influence the success of digital libraries based on the perspectives of the Information Systems. The unit of analysis of this study is the individual student, academician and researcher. The main reason it is viewed and analysed from the users' perspective is because, in reality, digital libraries should be continuously developed and enhanced not only according to users' behaviour and preferences, but taking into consideration the information and system qualities being served to them. Thus, taking the users' perspectives is a crucial factor especially in analysing the success of an academic digital libraries' performance. The main reason behind this is that an academic digital library is designated for a special community that requires a range of academic knowledge and information. Each research community has its own context of the usage where the usefulness of the system in facilitating the relevant needs can be investigated through analysing the performance of the digital libraries as IS Success. As a result, the digital library performance based on IS Success dimensions and measures can be used as indicators in the Digital Libraries' evaluation process.