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Design and Development of a Prototype ICT Skills Information Resource for Research Projects using TPTF Model

Oduronke Temitope Eyitayo
Department of Computer Science
University of Botswana
Gaborone, Botswana

ABSTRACT

The broad goal of this research was to analyse ICT skills need of final year undergraduate students, design and develop a prototype ICT skills information resource that will help them find the information required for their final year research projects. The analysis was based on the Task Person Technology Fit (TPTF) model which integrates elements of different theories and research models for the information needs analysis part of the study. This included computer self-efficacy (CSE), task fit and technology fit (TTF). The prototype system was created over ten research phases. The results of the analysis stage revealed that students were not well equipped with advanced ICT skills, which is what is needed for research projects. The three hypotheses posed that relate to the fact that there was no relationship between the students' current skills and the skills they need for their research project were also found to be true. Results from the evaluation revealed that the tool developed will be accepted, adopted and used by students. The study provides a conceptual framework for individuals, organisations, and information system community to be able to study the skills needs, as well as develop appropriate ICT Information resource that will meet the needs of the target group. The ICT skills Information Resource will empower the students to handle more complex tasks and motivate them to use more advanced features of the package.

Keywords: *Task Person Technology Fit, Self-Directed Learning, ICT Skills, Research Projects*

1. INTRODUCTION

Skills associated with ICTs are increasingly taken for granted at all stages of a student's university existence [1]. Almost any university expects students to have appropriate computer skills. In fact, most universities assume that new students are computer-literate when they arrive in contrast to past expectations that all new students would need some basic computer training [2]. The assumption is that these skills taught at the beginning of students' career would be able to carry them through the course or university life. Some institutions are considering eliminating introductory computer courses with the expectation that students will demonstrate adequate computer knowledge through the proficiency examination. This assumes that students have acquired both computer knowledge (concepts) and computer skills (applications) in high school or through other personal experiences [3]. However, research shows that this may be more of a perception than reality [4]. In a study carried out by [2] on the computer literacy of students majoring in computer information systems (CIS) at Georgia State University in the USA, the results of the two-month pilot showed that 28.4% of graduate students failed to pass all six exams. For undergraduate students, the results were much worse with over 50% of CIS undergraduate majors not being successful.

This researcher has been involved for several years in supporting final year undergraduate and graduate research students at the University of Botswana and has noticed, in particular, a lack of basic ICT knowledge as students struggle with most computer applications. Most of the students spend a lot of time on simple ICT tasks, which indicate lack of adequate ICT skills. Sometimes, due to lack of skills, students use some of the ICT tools in most inefficient ways. A student for example can type the table of contents for a document separately and keep changing the pagination in the table each time corrections are made. A fundamental question in this study is: do institutions of higher learning adequately prepare students to use these technologies?

Accordingly, this study focused on addressing two main research problems. The first involved determining the fit in the ICT skills required by final year students for the completion of their final year projects using the Computer Self-Efficacy constructs and Task-Technology Fit (TTF). The second was to design and develop a prototype information resource to meet these needs.

The objectives of the research were to:

1. Identify the ICT skills of UB final year undergraduate students
2. Identify the fit between ICT tools and skills of UB final year undergraduate students based on the tasks of completing their research projects.
3. Design and develop a prototype information resource based on the established fit.

2. REVIEW OF RELATED LITERATURE

In recent years, many researchers have argued for the need for a more embracing definition for the term which

assumes attributes beyond computing competency [5]. One common emerging term is ICT literacy. The emerging use of the broader term ICT literacy includes more recent dimensions of technology brought about by such developments as networks and Internet; however the definition above has survived the advances of technology and underpins the contemporary understanding of ICT literacy [6]. For purposes of this research, *ETS* definition of ICT literacy will be used. This is defined as the ability to use digital technologies, communication tools, and/or networks to solve information problems in order to function in an information society[7]. This includes the ability to use technology as a tool to research, organise, evaluate, and communicate information and the possession of a fundamental understanding of the ethical/legal issues surrounding the access and use of information. From the literature survey, the ICT skills required at undergraduate level are those outlined by [6] as well as two additional competencies as reinforced by other authors [8,9]. The six ICT skills are summarised as the ability to: independently operate personal computer systems; use software for preparing and presenting work; use internet and its various features; access and use information from WWW; use an eLearning platform and perform data analysis with a computer package.

[10] describes several main methods by which Higher Education institutions typically integrate computer literacy training into undergraduate programmes: Distribution Requirements; Core Curriculum; Correlated Courses; Freshman Studies; General Education Module; Certification of proficiency and Integration into all courses. Each of these models has its own advantages and disadvantages. For example, skills taught at the freshman or general education level are most likely lost by the time they are required for a project. The fact that training is provided in computer and information skills at the beginning of the academic year is referred to as a structural difficulty by [11]. When ICT is integrated into courses, some specific skills not related to those courses are not taught and so they are never learnt. Looking at [10]'s classification, the University of Botswana uses the General Education Module approach to increase students' general education experience. However, looking at the requirements for ICT competencies, it is evident that this model will not meet the ICT competency requirements for a research project, thesis or dissertation. This is because the course is taught at first year and the skills taught do not cover the whole experience required in the university. Also when students are taught in the first year, they are likely to forget the skills before their final year.

The issue of how and where students learn ICT skills can affect the quality of ICT skills learnt. Some skills might not even be learnt and students may never know such skills do exist. [11] argue that with the power of the Internet, the teaching and learning transaction is exposed to unfathomable amounts of information. A lot of information could also be found in manuals and through experts. [12] however cautions that information of mixed or unknown quality may even be worse than not having information at all. A survey of European universities' skills in ICT from the students' point of view revealed that the main sources of help and support for ICT skills development of both new and established students were friends and family, followed by self-tuition [13]. [1] investigates if students' ICT skills exist in a form that answers the universities ICT requirements. The evidence presented in his paper suggests that for the majority of students, their ICT skills were either self-taught or taught by family and friends in the context of general leisure or interest -activities but not focused for educational environment. A study by [14] however shows that high usage does not necessarily translate to better self efficacy. For the young individuals and for individuals with high educational level, the main way of obtaining IT skills is through an educational institution [15]. This is significant in that it implies that most skills have to be included in the ICT curicula

One major way that have been used in testing student knowledge of ICT skills is self reported competencies. A self-report survey is an inventory that is reported by the subject and it often asks direct questions related to perceptions, attitudes, or intended actions ([16]. Management information system (MIS) researchers have developed models to study the software utilisation choices of end users. One commonly employed model is the Technology Acceptance Model (TAM) [17]. Davis' research examines external variables that determine or influence attitude towards IT use. TAM however does not consider user characteristics, nor does it consider task characteristics. [18] developed the Task-Technology Fit (TTF) model which combines task characteristics and technology characteristics in an attempt to develop a more comprehensive model. The TTF model is significant in introducing task and fit, but it again does not consider user characteristics. [19] applied the concept of Computer Self-Efficacy (CSE) to explain user choices. However the study concentrated on CSE and did not consider task or system characteristics. Bani-Ali (2004) developed a model combining fit among CSE, task and system characteristics to examine relationships on how those factors affected performance and system utilisation. He called this model task-person-technology fit (TPTF), which combines CSE and TTF. This model therefore looks at fit in relation to task, technology and user characteristics. According to [20], in the TPTF model, computer self-efficacy is extended by examining how computer skills might empower individuals to handle more complex tasks and motivate them to use more sophisticated systems or more advanced features for the same system. His study found that those with high CSE are more likely to use information systems, and experience higher performance in their use.

[21] extended the study of Bani-Ali's work to the realm of online social networking (OSN) using the same TPTF model. In his study, he found out that CSE is positively related to both task and systems characteristics. He concluded that users with higher levels of CSE will use more complex OSN systems to perform more difficult tasks. One implication of the results is that OSN developers must understand the effects of CSE fit and its effect on individual performance and use. He further explained that in order to develop OSN

systems where members perform well and exhibit high OSN system use, the relationships between CSE, task and OSN system characteristics must be considered during the development. The better the fit between these factors, the more likely that users will perform well and use the OSN systems. As part of his conclusion, he stated that online, virtual or real training courses, improved manuals, help applications and similar items may help to increase user CSE, which in turn leads to increased performance and use. According to [21], "If users are knowledgeable and confident in abilities to use the applications, they will perform better and use the OSN systems more".

The current research therefore uses the TPTF model to test the relationships between CSE and TTF in a final year undergraduate studies environment. The degree of internal coherence among computer self-efficacy, task characteristics, and technology characteristics is used to determine the attributes of the clusters that associate with the highest performance and utilisation. The study used this relationship to model a prototype to provide a better fit between these constructs. The better the fit between these factors, the more likely that the users will perform well and use the tools appropriately for their research work. This is with the hope that this will help to increase user CSE, which in turn will lead to increased performance and use.

In this process, user centred design (UCD) is identified as the most effective approach for the design of the prototype. The goal of user centred design is to create a system that matches the workflow and mental model of the expected user community [22].

Elearning is defined as the application of ICT in a wide array of solutions that improve knowledge and performance [23]. Elearning needs a framework that will address the design, development, evaluation and sharing of digital content. [24] developed a digital framework to guide the development of digital learning content that can be deployed in various pedagogical frameworks whether they are content-driven or process driven. His digital framework is based on content, design, development, as well as evaluation of digital content models. Sound instruction design practices and the development of effective online teaching and learning strategies are based upon a sound theoretical framework and can contribute towards students' successful online learning experiences [25]. Instructional design is concerned with the promotion of processes that lead to successful learning regardless of the delivery medium being used and needs to be based upon appropriate learning theories [26]. In this case principles from adult learning were found to be the most relevant for the design.

Most theories of adult education place great value on prior learning and experience of adults, as well as relevance to the learner. Adult learning requires building on this prior learning, using methods that treat learners with respect, and recognising that people have different learning styles and have a variety of responsibilities and time commitments. The optimal role of the adult learner in the learning situation is that of a self-directed, self-motivated manager of personal learning who collaborates as an active participant in the learning process and who takes responsibility for learning [27,28]. Although this study is not about the adult learner, quite a number of the principles related to the adult learner are applicable to learning online. A major reason is that the online learner is mostly a self directed learner.

In the andragogy theory developed by [29], four key principles of adult learning are identified. The principles are that (i) adults need to be involved in the planning and evaluation of their instruction; (ii) experiences (including mistakes) which adult learners bring to the training environment, provide the basis for learning activities; (iii) adults are most interested in learning subjects that have immediate relevance to their job or personal life; and (iv) adult learning is problem-centred rather than content-oriented [30].

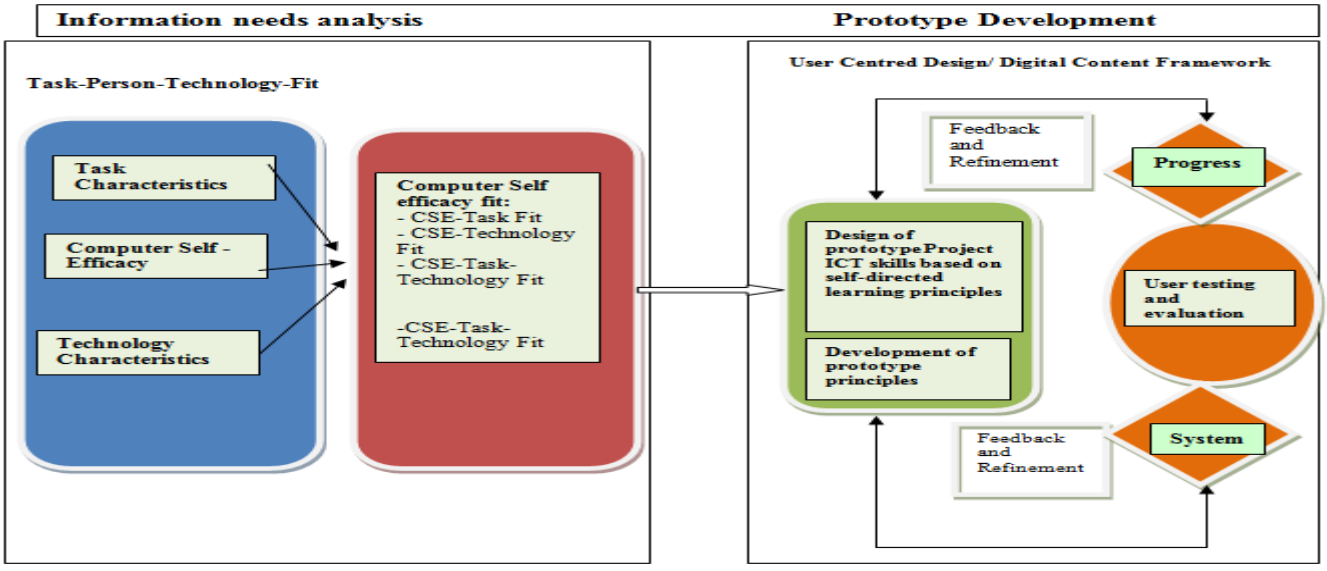


Figure 1: The Research Model

The implications of this theory for design of the information resource are that the:

(i) Tasks to be included are those identified and confirmed by final year students and their departments as required skills. This is based on the principle that adults need to be involved in the planning and evaluation of their instruction.

(ii) Design will concentrate on tasks students need to perform in their final year project.

This is based on the principle that adult learning is problem-centred rather than content-oriented.

(iii) Content of instruction will concentrate mainly on final year project tasks; so that final year students can find the information they need easily. This is based on the principle that adults are most interested in learning subjects that have immediate relevance to their job or personal life

(iv) Students are told direct steps on how to perform a specific task at a time, without the normal long process of computer instructions. Students' previous experience will be tapped into, since they already know how to use computers and just need specific information on how to perform specific task. Instructions will therefore be broken into chunks where students can find answers to questions on "how do I perform a particular task in an application"? This is based on the principle that student previous experiences provide a basis for learning. Also the role of the student in the learning situation is that of a self-directed, self-motivated manager of personal learning who takes responsibility for learning.

The result of the analysis phase provided more insight into the design for the prototype online resource that is intended to help increase user CSE, which in turn would probably lead to increased performance and use. Using the UCD, a prototype was developed based on the association and identified competencies across the various departments. The design also made use of the adult learning principles and the development was mainly based on the SCORM standard.

3. RESEARCH MODEL AND METHODOLOGY

Figure 1 shows the two parts of the research model: the information needs analysis and the prototype development. In the information needs analysis aspect, specifically, interactions between CSE, task and technology characteristics are examined individually and holistically. From the result of this interaction, cluster fit is used in the development of the prototype model. The prototype design aspect of the study, comprises the design, development and testing and it applies the principles of user centred design and digital content framework in developing the prototype ICT information resource.

The protype system was created over ten research phases: In the first phase, the initial instument was created. The survey instrument was developed to measure variables associated with computer self-efficacy, task characteristics and technology characteristics. This instrument was largely based on prior studies by researchers such as that of [18,19,20,21]. Validity and realibility tests of the derived instrument are conducted during the pre-study as well as with the main study. In the second phase it was distributed to subject experts, mainly staff members in the university who are in the ICT domain to check the survey's content validity and item clarity and conciseness. The third phase involved pre-testing the revised instrument with a few students. In the fourth phase, the measures were evaluated for internal consistency. After developing the final insrument and receiving the final data, the measures were evaluated for constuct validity through exploratory factor analysis (using principal component analysis) and for internal consistency (reliability) via item-to-total correlations and Cronbach alpha before testing the research propositions. The fifth phase involved verifying validity of the constructs and measurements, and data analyses using percentage frequency analysis, cluster analysis and ANOVA to access research propositions.

The sixth phase involved the identification of the contents of the prototype and the design of the prtotype based on the result of the analysis. While the seventh phase involved the development of the prototype using eXe and HTML based on the design. The eigth phase involved the evaluation of the prototype with final year students who volounteered in a laboratory environment. In the ninth phase, the measures of the evaluation data were evaluated for constuct validity through exploratory factor analysis (using principal component analysis) and for internal consistency (reliability) via item-to-total correlations and Cronbach alpha before testing the research propositions. At the tenth phase, after verifying validity of the constructs and measurements, the data analyses were conducted using percentage frequency analysis to access research proposition for the design aspect.

ICT information resource was designed based on identified competencies across the various departments. As stated earlier, the subtopics and levels identified were those in which 80% and below of the population studied were not confident. The aim of the resource is to give appropriate answers to specific questions students might have while working on their undergraduate research projects.

4. DESIGN AND DEVELOPMENT OF THE ICT INFORMATION RESOURCE

This phase focused on the design of the prototype ICT information resource. The prototype information needs analysis carried out helped to determine what the ICT

information resource should contain. Confidence in accessing online courses was used to determine if eLearning would be a good medium to deliver the content.

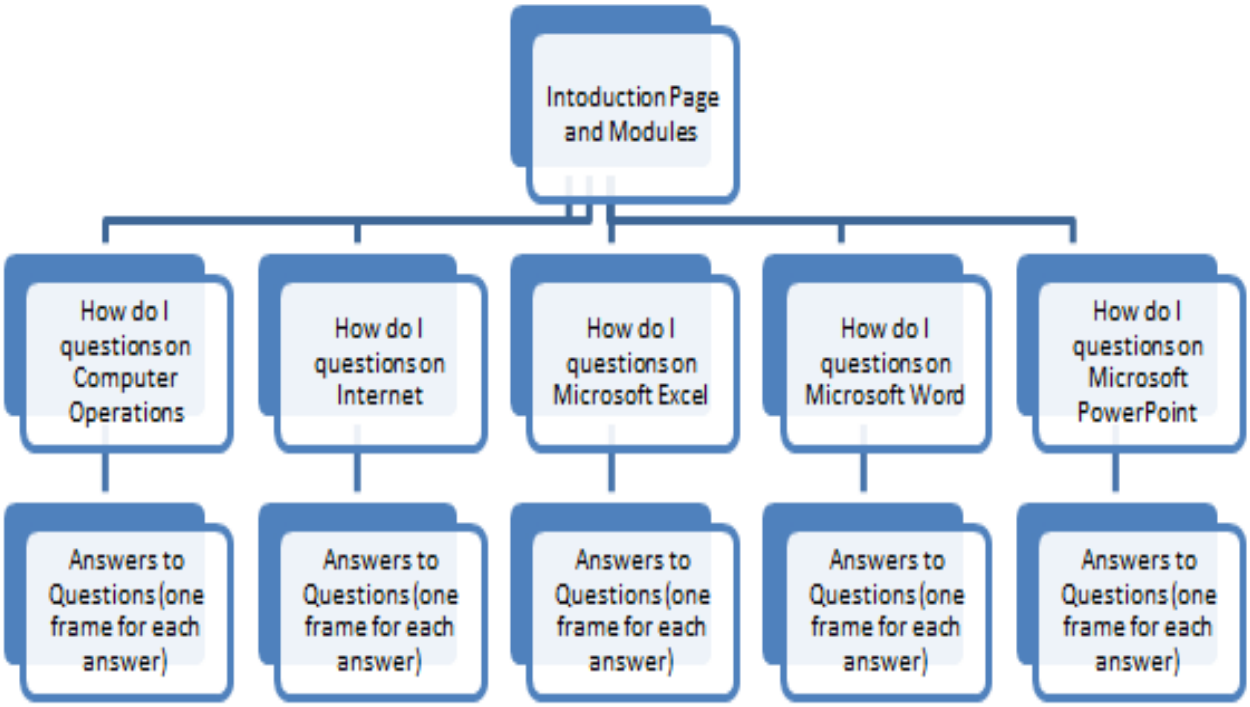


Figure 2: Structure of ICT Information Resource

As discussed in the methodology, the Information Resource will allow students to check and find what they want, and easily print or download what they find, with little or no distractions and minimal graphics. The structure of the information resource is a standard hierarchical arrangement with a capacity for non-sequential navigation following the [31] hierarchical model and the digital content framework. In the design, lessons learned from adult and self-directed learning, as highlighted in the literature review, are taken into consideration. The components taken into consideration are relevance/ involvement, previous experiences and control over learning.

The design process also involved gathering and structuring of the data that was included in the information resource. Data was gathered from the web, textbooks and help menus on the various questions and answers for each of the modules. The questions and answers were then carefully selected, broken down into steps and tested. Part of the design was also ensuring that the instructions were for Microsoft Office® 2007. The instructions were also tested to make sure they were correct. Screen shots were added as part of the answers where they were needed for clarity. The questions and answers were then compiled in Microsoft Word®. The compilation and testing took over two months.

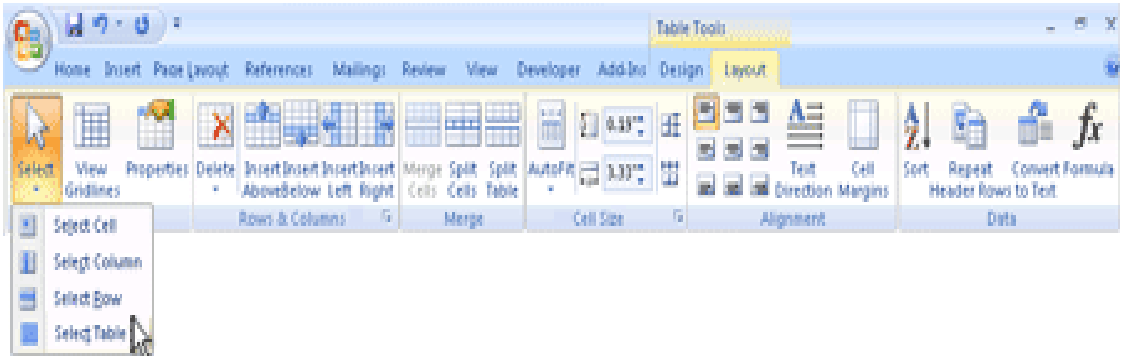
The content of the ICT information resource was developed using eXe which is a freeware eLearning xHTML editor following the SCORM standard. The version of eXe used was eXe –ready2run version 1.04. The pages were uploaded into the elearning content manager - Moodle. eXe offers a choice of style sheets and is a simple way of creating html pages, and adding pictures or online journal articles to a page. One does not require an understanding of HTML to use eXe, neither is it necessary to be a specialist web author. eXe uses an easy HTML editor or you can paste from Microsoft Word®. There are two stages to using eXe: the first is to create the materials using eXe on your local computer and the second is to export them as web pages to be uploaded into Moodle.

Various activities called “iDevices” are already designed and built into the eXe package. Based on the literature review, initial decisions were made for implementation in the development. Decisions on text design, screen design and navigation were made. The contents were divided into five modules. Each question was developed as a Re-usable Information Object (RIO), with the creation of special idevice created referred to as questions and answers. Each answer is on its own page.

***Q**: How do I insert my tables from Microsoft Word or Excel into a PowerPoint Slide?*

Answer:

- To copy a table from an Office Excel 2007 worksheet, click the upper-left cell of the table that you want to copy, and then drag to select the table.
- To copy a table from an Office Word 2007 document, click the table that you want to copy, and then under **Table Tools**, on the **Layout** tab, in the **Table** group, click the arrow next to **Select**, and then click **Select Table**.



- On the **Home** tab, in the **Clipboard** group, click **Copy**.
- In your Office PowerPoint 2007 presentation, select the slide that you want to copy the table to, and then on the **Home** tab, click **Paste**.

NOTE Before you paste your table onto the slide, make sure that you have clicked on the slide itself and not on a placeholder with a bullet to add text.

Figure 3: Example question and answer from PowerPoint®

One major problem encountered during the creation was that text copied from Microsoft Word® had some hidden codes that display when the pages were shown in Moodle. This problem was resolved by cleaning the data using a text editor before pasting it in eXe. Also all the screenshots could not be included by pasting and they had to be inserted as objects in the appropriate page. The process of inserting the screen shots made the development process longer.

A Moodle SCORM course called LIS900 was created by the lecturer in charge of administering the Moodle server. After creating the ICT information resource in eXe, it was then exported as a SCORM package. This was then uploaded into Moodle. Figure 4 shows a screen from Moodle uploading the SCORM package created in eXe. A total of 104 questions and answers were presented in the prototype ICT information resource.

Formative evaluation was conducted during the package development. The formative evaluation was done by two staff members involved in teaching Computer Literacy Laboratory sessions. The purpose of this evaluation was to get feedback from experts in the field in terms of instructional quality and content validity. Their comments were used in the review of contents after which students were invited to interact with the prototype. Prior to inviting them, the students were asked to register and accounts were created for them. Some screenshots from the package are shown in figures 4 to 6. After the opening screen, users can view all the questions at once on the next screen and then proceed to a question or to a module. Users are directed to a list of questions on a particular module as shown in figure 4, where you can choose any option. The last screen in the structure directs users to the answer to their particular question. Figures 5 and 6 are examples. Users can also perform a direct search of any content in the ICT resource.

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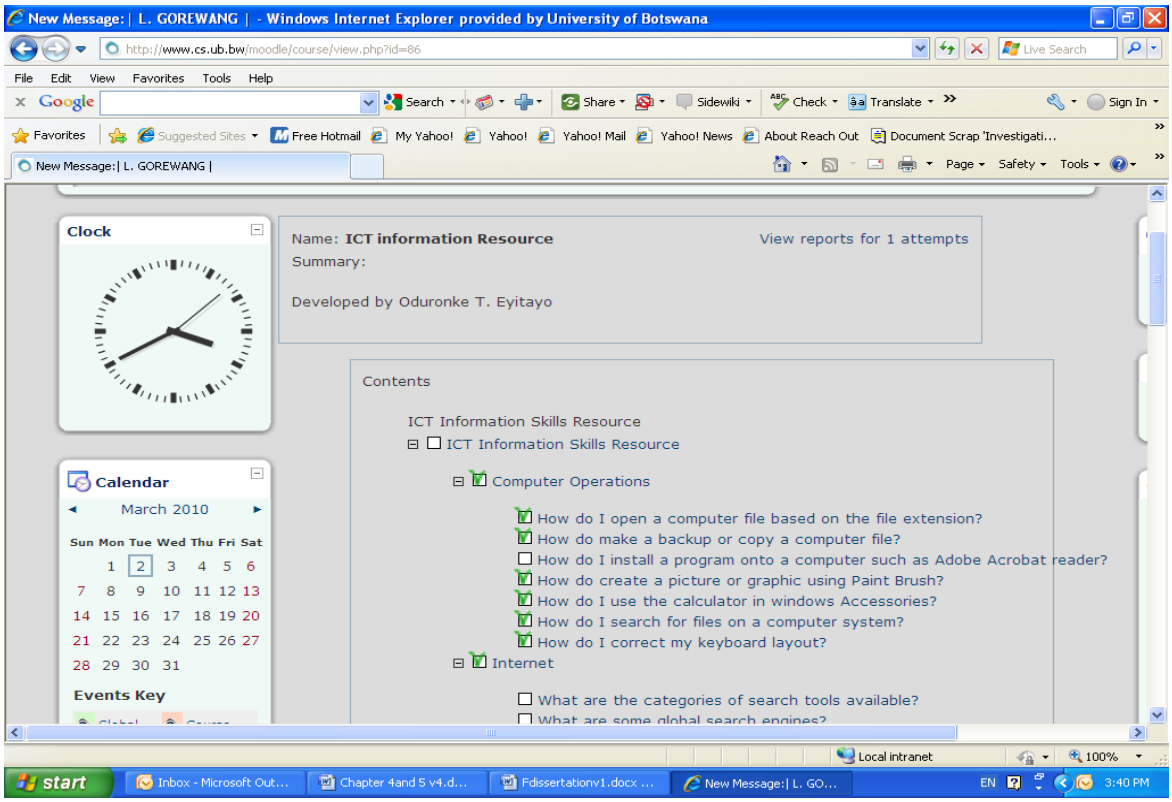

Figure 4: Modules Screenshot of ICT Information Resource

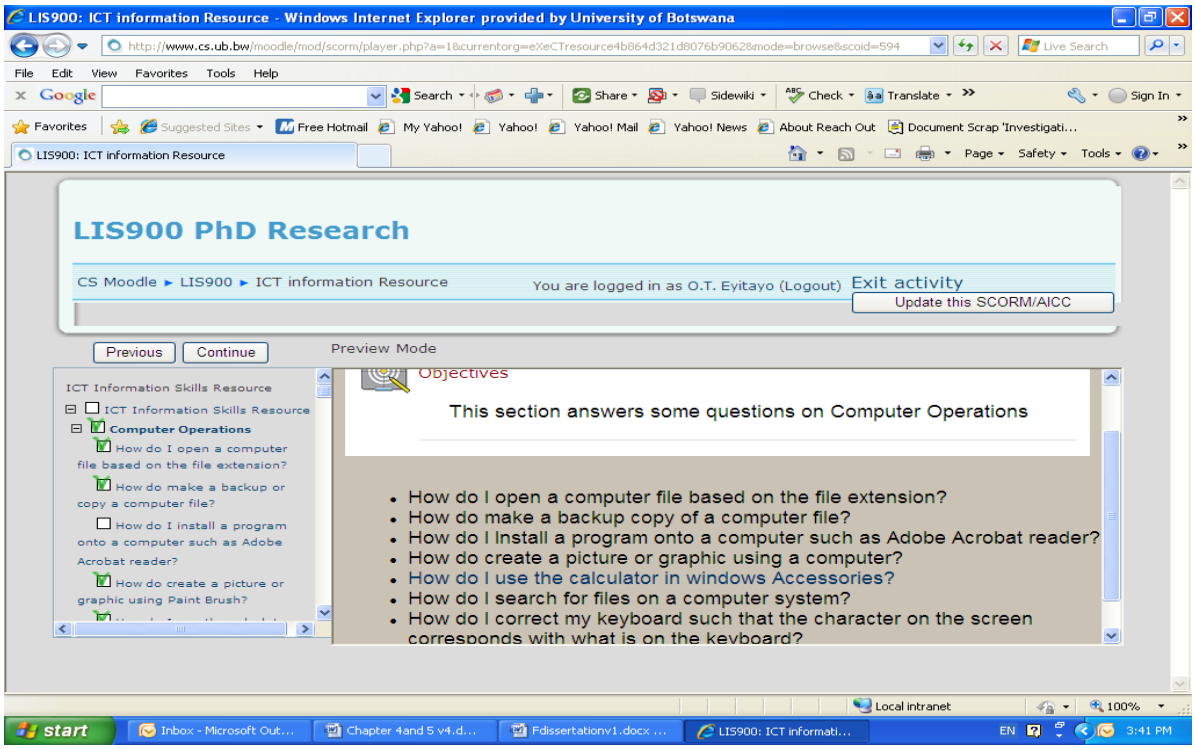

Figure 5: Computer operations screenshot of ICT information resource

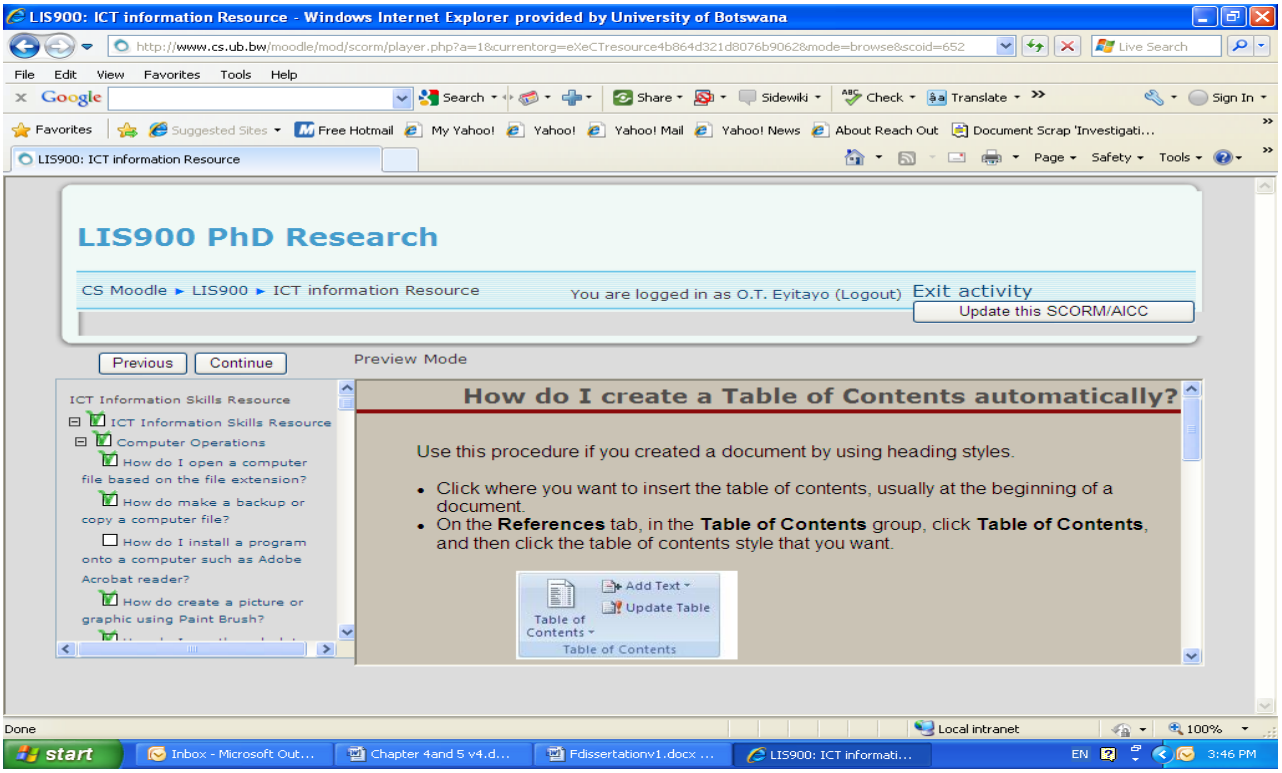

Figure 6: Sample screenshot of ICT information Resource from Microsoft Word®

5. FINDINGS FROM PROTOTYPE DESIGN

Six sessions were organised to conduct the summative evaluation of the resource. A total of forty-four (44) students evaluated the system. The system was introduced to the students and they were allowed to interact with it and ask questions. At the end of the session, a questionnaire comprising four (4) sections was given to the students to complete. The first section was on demographic information of the respondents. The second section had nine (9) items that were based on the perceived potential usefulness and were adapted from [17] instruments. The third section had ten (10) items that were related to the task technology fit using a construct from [32] factors influencing the utilisation of Personal Computers (PCs). The last section of the questionnaire was an additional question about respondents overall comments on the prototype.

Based on the evaluation, observations, comments and question from the students, the design of the information resource can be adjudged highly successful. The perceived potential usefulness and task technology fit were quite high. Over 90% of the students in the evaluation team agreed that the system has been designed with an understanding of the ICT skills they need, they were satisfied with the functionality of the system and will give them greater control over the ICT skills they need for their research project, and that the system will enable them to complete their research project more quickly and increase the quality of their report. It is therefore expected that with the high level of their satisfaction with the perceived potential usefulness, and Task Technology Fit, the ICT information resource will be accepted, adopted and used by the students.

6. DISCUSSION & RECOMMENDATIONS

In view of the fact that most students were lacking in ICT skills that are useful for their research project, it is recommended that all final year students doing research projects should learn some ICT skills that will make research work easier for them. Some of the skills identified as needed were: Internet and WWW advanced skills, Microsoft Word® advanced skills, Microsoft Excel® advanced skills and Microsoft PowerPoint® skills.

It is recommended that ICT advanced literacy skills should be integrated into the research methods course in the various departments and faculties. Departments and faculties can use the ICT information resource specifically to train their students, by focussing on those application types that are most relevant to their students and the professional field to which their programmes related. It is also recommended that fluency with technology be treated with great importance.

The university should provide students with an IT fluency centre where individuals can concentrate on developing their skills. The University could constitute technology teams of academic staff, IT staff, librarians and students which will subsequently develop and support technology activities for research projects for different disciplines. A wide range of short-format, hands on workshops and demonstrations is recommended in which

students can be given individual attention. Technology is ever changing and these changes will keep affecting the needs of undergraduate students and the prototype designed. It is therefore important that future research continues to address the changing technology needs of undergraduate students.

7. CONCLUSIONS

This study has determined the ICT needs for research projects as well as developed a prototype ICT information resource. A fundamental question that the researcher raised at the beginning of the study was 'do institution of higher education adequately prepare students to use technologies?' In determining the University of Botswana ability to use technologies, students ICT needs, interactions between CSE, task and technology characteristics of final year students were examined individually and holistically. The process of determining the ICT information needs of final year students and developing a prototype contributed significantly to a better understanding of the ICT information needs of final year students.

The results revealed that students were not well equipped with advanced ICT skills, which is what is needed for research projects. This contributes to other researches that conclude that students are not involved in advanced uses of technology [33,34,35]. The three hypotheses posed that relate to the fact that there was no relationship between the students' current skills and the skills they need for their research project were also found to be true. From the result of this interaction, cluster fit was used in the development of the prototype model. The prototype design was based on User Centred Design (UCD). Several phases in the cycle were carried out: design, development and evaluation. Results from the evaluation revealed that a useful tool has been developed that will be accepted, adopted and used by students.

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