The impact of virtual learning environments on the practical skills of open distance learning students in electrical engineering

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***Abstract*— Open distance learning (ODL) education has been developing rapidly in South Africa. The main reason behind the growth is the demand for online studies created due to the corona pandemic. The ODL system involves study that is not limited by geographical boundaries and extends to many knowledge areas electronically. In practice the study tends to extend to knowledge areas beyond those offered by the standard contact or traditional universities. At the University of South Africa (UNISA), the adoption of the ODL framework to theoretical subjects has been successful by making use of the Sakai virtual learning environment (VLE). The practical subjects or practical knowledge areas on the other hand have previously been taught face-to-face. Therefore, the practical modules have not been effectively taught online particularly in the electrical engineering curriculum. This issue can contribute to graduates who are unskilled in the practical component of a knowledge area, which can lead to unemployment. Virtual learning environments (VLE's) play a vital role when it comes to teaching and learning online. In this paper, the impact of VLE's on the practical skills of students and practical knowledge is investigated. This is done by analyzing the change in pass rates of students in a practical subject such as Electrical Engineering when taught face-to-face as compared to when taught through a VLE such as Sakai online. Two groups termed as emerging centered learner (ECL) and a developed centered learner (DCL) are investigated. The method evaluates students who study electrical engineering practical module part-time. In this paper the Sakai platform was used as a VLE to teach and then evaluate students in the electrical engineering practical module. The practical guide with the full set of experiments was uploaded on Sakai under additional resources. The students were given the necessary guidelines and tasks via Sakai online, examined and then the pass rates achieved were analyzed at the end of the program and compared to the pass rates achieved using previous face-to-face teaching method used for the same practical's. It was determined that a VLE can be used to improve the pass rates of a practical module such as electrical engineering taught online in ODL.**

Keywords*— *Electrical Engineering, Open Distance Learning (ODL), Practical's, Pass rates, Sakai, Virtual Learning Environment (VLE).

I. Introduction

Open distance learning (ODL) has transformed tertiary education around the world [1]. ODL has been able to surpass many obstacles to education that occurred in conventional distance education, because it is more practical and flexible brought about by its easy access to electronic media [1]. ODL is a model of education that follows a delivery approach to reach-out to as many students as possible in South Africa and countries beyond its borders. ODL has a holistic approach and is inclusive in its service to the whole population including people with disadvantages or disabilities [2]. The main aim of ODL is to give people access to multidisciplinary education to all those who need it. Through this approach education can be spread to a large population in and outside the borders of any country [2].

In Africa, there are a few ODL institutions of higher learning. These institutions include the University of South Africa (UNISA), the Zimbabwean Open University (ZOU), the Open University of Tanzania (OUT) and the National Open University of Nigeria (NOUN). The most common problems reported in studying at ODL institutions is problems associated with accessing ICT tools, poor feedback from lecturers and shortage of study materials [3]. The developed and developing countries are using ODL to meet the pedagogical needs of students in the turn of the century. Educational institutions in developed countries, are changing from the face-to-face contact teaching mode of higher education to an ODL mode using information and communication technology tools [3] to facilitate the change. Therefore, many universities are offering some form of online courses in the current dispensation. Although ODL is quite a slow process, it is quite an effective channel for giving a second educational chance to adults from various fields of expertise. ODL is a mode of education where the student's study on their own [4]. ODL is quickly becoming very relevant around the world [5]. The advantages of ODL to certain Universities is detailed in [5]. The change from ODL to Open Distance e-Learning (ODeL) has occurred via the use of virtual learning environments (VLE's). VLE's include applications such as virtual laboratories that can be used in Electrical Engineering, learning utilizing computers and learning management systems [6]. Virtual Reality based Learning Environments (VRLE's) enable students to get

knowledge by interacting in a sensory environment which gives feedback. It can increase student pass rate in their specific field of study. This knowledge acquiring process can be repeated with no cost, enabling students to slowly develop their own skills in a specific learning field [7]. The new teaching methods in ODeL enables students who could previously not get access to education, that is students who were previously disadvantaged to increase their skill set. Online assessments given by lecturers enable them to record the performance of students after every test.

The idea of getting a higher education qualification through full-time face-to-face, contact universities is a distant reality for most black South Africans who were not given the opportunities for higher education during the times of apartheid [8]. Most of these black South Africans are either in full-time employment, part-time employment, some temporary positions, unemployed and in some cases are unemployable [8]. Therefore, there is a high demand for the (ODL) mode of delivery of education emanating from these groups. The ODL framework enables these groups particularly those in full time employment to study and get a qualification while at their place of work.

Previous research clearly shows that there is a gap that needs to be filled, when it comes to 'transferable skills' that can be learnt by students in academic institutions and used in employment. 'Transferable skills' could include skills such as team work and taking leadership in a project. Although students must achieve academic excellence before they attain a degree, employers are searching for much more than deep knowledge and understanding of specific subject matter from students [9]. Specifically, employers need practical skills in subject matter such as Electrical Engineering which can be used in places of employment such as in the supply and distribution of electrical power.

Many articles on distance education focus on the advantages of distance education such as reaching many students and making education more convenient. However, some articles investigate the difficulties surrounding distance education. These difficulties include lack of technical support and poor feedback from lecturers which can lead to frustration and anxiety amongst students [10]. Also, it was observed that in online classes, students learned more than in face-to-face lectures but ended up less satisfied with the program [11]. The reason for this is that the instructor plays a part in learning as well as in the overall satisfaction of the students. Statistical methods such as those used in [12] can be used to determine the pass rates of students at the end of a distance learning programme.

In summary although many researchers determined that students can learn better and faster using VLE's in ODL education, there are still some pertinent questions that need to be addressed regarding this mode of delivery. Therefore, the research in this paper is based on the following questions; how can lecturers assist ODL students in developing practical skills using a VLE? Will the pass rates improve when a practical module is taught using a VLE as compared to the same practical module being taught using face-to-face contact approach? What are some of the challenges facing ODL students with regard to practical online modules?

This paper is divided into the following sections; section I is the introduction, section II a survey of VLE's, section III describes the methodology, section IV gives the results, section V the conclusion.

II. A SURVEY OF EXISTING VLE'S

There are many virtual learning management systems (LMS) or platforms available that can be used for teaching in the ODL environment. These include the Modular Object-Oriented Dynamic Learning Environment (MOODLE), Sakai, WebCT, educative, scholar360, FirstClass, Desire2Learn, verticeLearning, Blackboard and NetCampus. The details of the major LMS's used in different universities and their features are narrated in [13]. It can be seen from Table I below that the platforms Moodle and Sakai possess more features than the other VLE's.

TABLE I THE ATTRIBUTES OF MAJOR VLE'S [13].

LMS ATTRIBUTES	Sakai	Moodle	WebCT	Blackboard
Upload Documents	Yes	Yes	Yes	Yes
Online Content	Yes	Yes	Yes	No
Discussion Forum	Yes	Yes	Yes	Yes
Online Chats	Yes	Yes	Yes	Yes
Self-Evaluation	Yes	Yes	No	No
Assignment Submission	Yes	Yes	Yes	Yes
Student Online participation	Yes	Yes	Yes	Yes
Glossary	Yes	Yes	No	No
Student Groups	Yes	Yes	Yes	Yes
Drop Box	Yes	Yes	No	No
Learning Units	Yes	Yes	No	No
Statistics	Yes	Yes	No	No
Syllabus	Yes	Yes	No	No
Site Info	Yes	Yes	No	No
Study Material	Yes	Yes	Yes	Yes
Resources	Yes	Yes	Yes	Yes
Announcements	Yes	Yes	Yes	Yes
Calendar	Yes	Yes	Yes	Yes

III. METHODOLOGY

The practical experiments are done online by two sets of students. These are the emerging centered learners (ECL) which are basically the first year students and the developed centered learners (DCL) which are the second year more advanced students. The students are given access to a practical guide or a tutorial letter online which contains four sets of experiments. These experiments are designed as shown in Table II;

TABLE II PRACTICAL EXPERIMENTS DONE FOR ELECTRICAL ENGINEERING IN A VLE

Experiments	Weight	Objective

1.	Determining the values of circuit components using rms measurements	35%	Determine component values
2.	Power and Power Factor Correction	25%	Maintain the level of reactive power and reduce electricity consumption.
3.	Analysis of circuit resonance	20%	Determine resonant frequency
4.	Three phase balanced circuits	20%	To make the size of each phase the same
5.	Total Percentage	100%	

The practical guide or tutorial letter detailing the experiments is uploaded to a section of the VLE referred to as additional resources. In addition to the practical guide, a power point presentation which explains to the students how to connect the circuitry, a link to the simulation software 'NI Multisim' [14] and the study guide for the module are also uploaded to the additional resource site in the VLE. The practical guide and the power point presentation are meant to give the students as many detailed instructions as possible to enable them to perform optimally in the practical by a technique referred to as scaffolding [15]. Therefore, to answer the first research question which is "how can lecturers assist ODL students in developing practical skills using a VLE?", the answer to that question is lecturers can assist ODL students in developing practical skills when using a VLE by making use of the technique of scaffolding, whereby the lecturer gives as much information, instructions and detailed work process in the practical guide, tutorial letter or instructional guide for the practical. By doing so this enables students carry out the experiments in the practical module optimally even when working using the VLE online.

A. Simulation in Multisim

As stated earlier the practical guide, a power point presentation, link to the simulation software 'NI Multisim' and the study guide are uploaded to the VLE on the additional resource site. The link to the simulation software 'NI Multisim' is used by the students to download the simulation software, install it on their personal computers (PC's) and then run the experiments by following the instructions in the power point presentation and the practical guide from the comfort of their home. When the practical portfolio is completed the results of the experiments are uploaded by the students on the VLE for marking by the lecturer.

B. Utilization of the VLE Tools

There are several tools available on the Sakai VLE which have been previously shown in Table I. Some of these tools include; site info, announcements, statistics and additional resources. Most of the resources given to the students mentioned in section III.A are uploaded to the additional resource tool. As a result, the percentage utilization of the additional resource tool is highest as compared to the percentage utilization of the other tools. It can be seen in Fig. 1 that the percentage utilization of the additional resources tool is 98.8%. The next most utilized tool is the statistics tool of 0.7%. This tool is used to determine the number of downloads occurring for the resources given to the students.

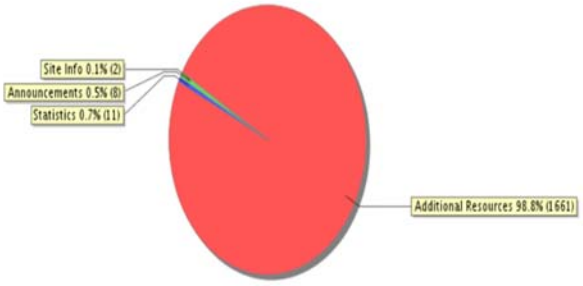

Fig. 1: Utilization of Sakai tools

C. Download of Resources Given to Students

The students access or download the resources used for learning from the additional resource tool on the VLE. The number of times each resource is accessed or downloaded can be used as an estimate of activity on the site. When the number of students in a class is known then each resource needs to be accessed or downloaded at least ones by each student indicating that each student gets a copy of each resource uploaded. The student number in the class pool for electrical engineering was 148 students. Therefore, each student downloaded the resource tool for the simulation software 'NI Multisim' at least 2.5 times. The number of times each resource is accessed or downloaded can also be referred to as 'HITS'. Table III below shows the number of 'HITS' per resource used for learning.

TABLE III NUMBER OF 'HITS' FOR THE RESOURCES GIVEN TO STUDENTS

Document uploaded to additional resource tool	Number of 'HITS' or downloads
The link to download the simulation software 'NI Multisim'	372
Power Point presentation	326
Practical Guide	257
Study Guide	208

The most highly accessed or downloaded resource is the link to download the simulation software 'NI Multisim'. As should be the case since the experiments cannot be done without the simulation software. The second highest most

downloaded resource is the power point presentation. This gives the students the instructions on how to connect the electrical circuitry. The third highest accessed resource is the practical guide. Again, this contains detailed instruction required by the students to perform the experiments.

IV. Results

The evaluation of the student performance when the practical module electrical engineering is taught online using the VLE as compared to previous face-to-face contact teaching of the same practical module is done at the end of the year using the pass rate of the students. The pass rate is the percentage of students who passed the course out of the total number of students in the class. The pass mark is 50%. The data for the pass rate is obtained from the exam mark online (XMO) system, that is part of the student learning management system (LMS) which forms the backbone of the Sakai VLE. The pass rate achieved in the practical module when the VLE is used for teaching versus when face-to-face practicals are conducted can be seen in Fig. 2. According to Figure 2 face-to-face practicals where done from the year 2014 – 2019. At the beginning of the corona pandemic in 2020 it became necessary to conduct the practicals online by using the Sakai VLE.

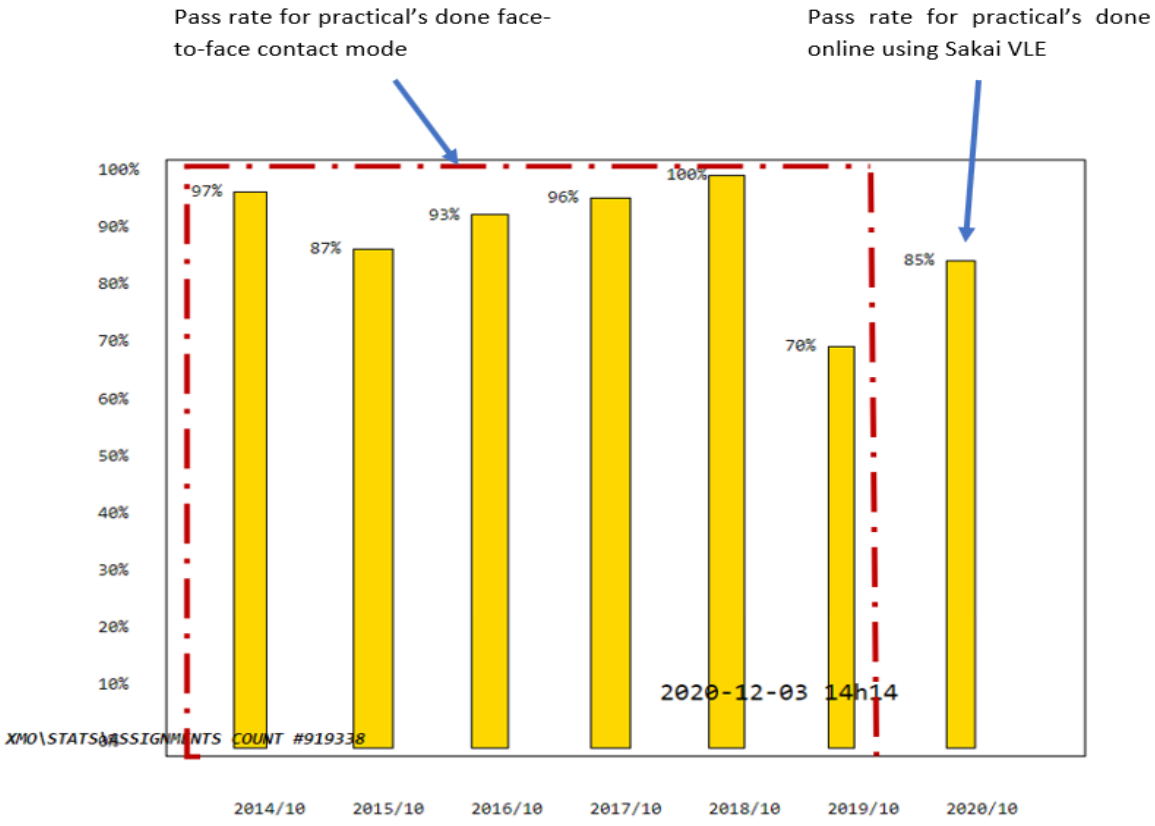

Fig. 2 Pass rates for the practical module when the VLE is used Vs face-to-face practical's

In Fig. 2, from the year 2019 when face-to-face practicals where conducted to 2020 during the corona pandemic when the VLE was used there is a slight improvement in pass rates from 70-85%. This indicates that simulation based learning done online using a VLE can be used to improve student pass rates, increase student learning and self-efficacy [16]. This answers the second research question which is "will the pass rates improve when a practical module is taught using a VLE as compared to the same practical module being taught using face-to-face contact approach?". The answer to that question is "YES" the pass rates can improve when a practical module is taught using a VLE as compared to face-to-face practicals.

Taking a closer look at Fig. 2, we note that although the pass rate increased from 70-85% for the years between 2019 to 2020. Overall the pass rate decreased from what the pass rates used to be between the years 2014 – 2018. The reason for this can be attributed to the fact that using a simulation software to conduct practicals online using a VLE requires confidence in the utilization of the simulation software. The confidence in the utilization of the simulation software can only be developed with time. The confidence and the experimental self-efficacy (ESE) [17] are negatively affected by the anxiety of using the simulation software for the first time. However, with time the confidence and the experimental self-efficacy (ESE) [17] in the utilization of the simulation software would

improve and the pass rates achieved in carrying out the practicals using the VLE would also improve in the coming years.

V. Conclusion

In conclusion, in this paper the module electrical engineering practical was taught using the Sakai VLE. Instructional resources such as the practical guide, power point presentation, link to software simulation 'NI Multisim' and the study guide were uploaded to the Sakai VLE tool called additional resources to be used by students in carrying out the practicals. The performance of the students was then evaluated at the end of the year by using the pass rates obtained from the exam mark online (XMO) system on the learning management system (LMS). It was determined from the pass rates that using a VLE to teach a practical module can indeed improve the pass rates of the students. However, the utilization of a VLE to teach a practical module requires attributes such as confidence and experimental self-efficacy (ESE) [17] on the part of the students. These attributes can be acquired over time and are adversely affected by anxiety when using the simulation software on the VLE. To answer the final research question which is "what are some of the challenges facing ODL students with regard to practical online modules? Some of the main challenges facing ODL students with regards to practical online modules is lack of information communication technology (ICT) tools and poor feedback from lecturers in an online environment which contributes adversely to the student anxiety levels in using a VLE.

Acknowledgment

We would like to acknowledge the University of South Africa for providing the resources used to teach the students and the Sakai platform and the ESKOM South Africa TESP grant for funding to publish the research.

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