



Sudan University of Science and Technology
College of Graduate Studies
Faculty of Education

Trends in Electronic Learning and Teaching in Engineering Education

إتجاهات التدريس و التعلم الإلكتروني في التعليم الهندسي

By

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Initiation

إستهلال

قال الله تعالى في محكم تنزيله:

بسم الله الرحمن الرحيم

﴿وَمَا أُوتِيتُمْ مِّنَ الْعِلْمِ إِلَّا قَلِيلًا﴾ ﴿٨٥﴾

سورة الإسراء ١٧ الجزء ١٥

Allah Almighty says in his precise holy book:

In the name of Allah the most gracious the most merciful

85. “And of knowledge, you (mankind) have been given only a little”

Sûrah 17. Al-Isrâ' Part 15

Dedication

To:

My family,

My friends,

My colleagues,

My teachers,

My students,

And to my inspiration, my mother, may her spirit rest in peace

I dedicate this unpretentious effort

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First, I thank and praise God, as without his bounty this study would never have been completed and presented in this final form.

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Abstract

This study is an attempt to document trends in online engineering education in some developing countries in Africa, as well as to compare the current practice in online engineering education in developing countries with practices in developed countries.

The rationale of doing this research is the lack of research in this field in Africa in spite of the importance of engineering education and the implementation of ICTs in this field.

The main research question was:

What trends are emerging in online engineering education in developing countries?

As a limit on location, this research was carried out at two South African universities; the researcher used a mixture of both quantitative “survey” and qualitative “phenomenological” studies. Thus, survey questionnaires and interviews were used as primary data collection methods.

The most important findings are:

- Online methods in engineering education increase the breadth and scale of engineering education in South Africa.
- The quality of engineering education can be dramatically improved through collaboration among institutions.
- Materials for engineering education can be utilized across institutions, thus increasing quality and driving down costs.
- Engineering education offered in a blended format is likely to become much more prevalent in the upcoming years.
- Engineering students and lecturers are becoming more used to the benefits of teaching and learning in an online or blended format.
- New trends and technologies will emerge in online methods in engineering education.

الخلاصة

هذه الدراسة محاولة لتوثيق الاتجاهات نحو تعليم الهندسة عبر الإنترنت في بعض البلدان النامية في إفريقيا، وكذلك مقارنة الممارسات الحالية للتعليم الهندسي عبر الإنترنت في البلدان النامية مع الممارسات في البلدان المتقدمة.

السبب الرئيس الذي دعا الباحث لإجراء هذا البحث هو ندرة الأبحاث في هذا المجال في إفريقيا والدول النامية، وذلك على الرغم من أهمية التعليم الهندسي وضرورة توظيف تكنولوجيا المعلومات والاتصالات في هذا المجال.

السؤال البحثي الرئيس هو:

ما الاتجاهات الناشئة في مجال التربية الهندسية عبر الإنترنت في البلدان النامية؟ بالنسبة للحد المكاني لهذا البحث، تم تطبيق الدراسة على جامعتين من جامعات جمهورية جنوب إفريقيا، بمدينة كيب تاون، وكانت الدراسة مزيج من كل من "الدراسات الكمية المسحية" والدراسات النوعية المتعلقة بدراسة "الظواهر". وهكذا، تم استخدام الاستبانات المسحية والمقابلات المعتمدة على العينات القصدية كطرق أساسية لجمع البيانات.

أهم نتائج الدراسة جاءت كالتالي:

- طرق تدريس الهندسة عبر الإنترنت تزيد اتساع وحجم تعليم الهندسة في جنوب إفريقيا.
- نوعية مخرجات التعليم الهندسي تحسنت بشكل كبير من خلال التعاون فيما بين المؤسسات.
- استخدام مواد تدريس الهندسة عبر الإنترنت المصممة بوساطة المؤسسات المختلفة تساعد في زيادة الجودة وخفض تكاليف العملية التعليمية.
- هناك توجهات نحو استخدام الأسلوب الممتزج في تدريس الهندسة، ومن المرجح أن يصبح أكثر إنتشاراً خلال السنوات المقبلة.
- أساتذة وطلاب الهندسة لديهم الرغبة في التعليم والتعلم عبر الإنترنت أو المزج بين أساليب التدريس والتعليم التقليدي والإلكترونية.
- هنالك العديد من الاتجاهات والتكنولوجيات الجديدة في تدريس الهندسة عبر الإنترنت والتي ستبدأ في الظهور تباعاً.

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Chapter One

Overview

1.1 Introduction

The Engineers' Council for Professional Development (1947) has defined engineering as:

“The creative application of scientific principles to design or develop structures, machines, apparatus, or manufacturing processes, or works utilizing them singly or in combination; or to construct or operate the same with full cognizance of their design; or to forecast their behaviour under specific operating conditions; all as respects an intended function, economics of operation and safety to life and property.”

The concept of engineering has been in existence since ancient times when humans devised fundamental inventions such as the pulley, the lever, and the wheel. Each of these inventions is consistent with the modern definition of engineering: “exploiting basic mechanical principles to develop useful tools and objects” (History of engineering, 2012). Various specialisations in engineering occurred during different time frames throughout history. The second industrial revolution, for instance, which occurred before World War II, saw the advent of chemical, industrial, electrical, telecommunications, automotive and aircraft engineering as well as the mass production of goods.

The practice of engineering education began in the 18th century in the United States of America, where it started to take the shape that we currently see in various schools and universities across the globe. Engineering education can be defined as the activity of learning and teaching engineering sciences and engineering technology at the engineering schools, faculties, and tertiary education level. According to Dym, Agogino, Eris, Frey, and Leifer, (2005), “the purpose of engineering education is to graduate engineers who can design”. It can therefore be said that the goal of engineering education is to prepare people to practice engineering as a profession as well as spread technological literacy

(Douglas, Iverson, and Kalyandurg, 2004).

Instructors in engineering education originally started teaching their courses using the traditional classroom setup, just as has been done in other sciences and subjects. They later moved into laboratories and eventually workshops, trying to make use of new instructional technologies with each progression. It was during the second half of the 20th century that people began making use of computers in the instruction of engineering. Then, in the 1990s, online methods emerged and took a strong root in the teaching and learning process. The websites used, however, were poorly designed and lacked interactivity and hypermedia. The end of the 1990s saw online learning methods and design that took on a more modern form and layout which became more trusted by educators and designers in various fields and domains.

Because of the interactive capabilities of the Internet, specialists and researchers have been focusing on online learning in their research, this trend has been especially prevalent within the last ten years. Most of this research focuses on the evaluation of online methods, and attempts to present new technologies and strategies in terms of the use of the Internet as an interactive medium which enables learning. Some research regarding online methods and investigate concerns facing these technologies and strategies.

Despite the recent developments in engineering education “deficiencies in engineering education have been exhaustively enumerated in recent years” (Felder, Woods, Stice, and Rugarcia, 2000). Bourne, Harris, and Mayadas (2005, p. 17) ask: “Why has undergraduate engineering education lagged behind some other fields in adopting online methodologies?” and they answer this question partially: “Some of the special needs of undergraduate Engineering Education have not been well served by methods of online education.” These ‘special needs’ refer to the applied and design sides of engineering which learners need to master.

According to Bourne, Harris, and Mayadas (2005), the quality of online teaching and learning methodologies in engineering will steadily improve during the coming years as teaching and learning technologies improve. This includes the use of better simulations and course management tools. In addition, the introduction of more interactive and engaging learning experiences, which include constructivist methodologies, will improve

the quality of online teaching and learning in engineering. Bourne, Harris, and Mayadas (2005) also describe a few trends in online engineering education, these trends are:

- Online methods in engineering education will increase the breadth and scale of Engineering Education, thus extending the reach of institutions and the delivery of education to broader audiences.
- Specialty areas will leverage expertise among institutions, thus driving down the cost of replicating facilities at multiple institutions.
- The quality of engineering education output can be dramatically improved through collaboration among institutions. Online methodologies can be the driver that enables collaboration.
- Materials for engineering education can be utilized across institutions, thus increasing quality and driving down costs. Analogous to books that reach multiple institutions, simulations, computer-based training materials, and even course management systems can also be developed in collaboration.
- “Engineering education offered in a blended format is likely to become much more prevalent during the upcoming years. Engineering education will be offered with a range of blended percentages, ranging from all-Online to all-classroom instruction.
- As students and faculty become accustomed to the benefits of teaching and learning in an Online or blended modality, both will demand the opportunity to teach and learn online.” (Bourne, Harris, & Mayadas, 2005, p. 36).

These trends were the focal point of this study. The study assessed these trends and determined the assisting factors that play a role in the occurrence, or non-occurrence, of these trends in developing countries. The study also predicted future trends of online engineering education in developing countries.

1.2 Problem Statement

Even with the recent developments in online engineering education, little has been documented regarding it in developing countries, including all countries of Africa. Therefore, this study aimed to document trends in online engineering education in South Africa and tried to predict the future of online engineering education in that country.

1.3 Rationale of the Study

There are several reasons which motivated the researcher to do this study. Due to the researcher's experiences as a lecturer of some engineering courses and his background in e-learning and teaching with computers, this study was an extension of the previous knowledge and experiences of the researcher.

As well as this personal factor, a lack of research in this field in Africa encouraged the researcher to do this study; as many more studies need to be done in the African context on e-learning including online learning. In some non-African developing countries much—but not enough—research has been conducted on exploring, investigating, designing, evaluating, and understanding the pedagogical use and usage of ICT in education, for example in Chile, Malaysia, China, ...etc. (Draper, 2010; Budge, 2009; Hinostroza, Hepp, & Cox, 2009). Also regarding this issue, Howie (2009) declared that it is difficult to find empirical literature on the implementation of ICT in education in South Africa.

The researcher does not allege or claim that this research will fill or address this gap, but hopes that it will go some way in giving insights on online engineering education in developing countries in Africa.

1.4 Purposes of the Study

The purposes of this study are: to document trends in online engineering education in one developing country and to compare the current practice in online engineering education in developing countries with current practice in developed countries.

1.5 The Research Objectives

The objectives of this study are to:

1. Investigate the situation of online engineering education in South Africa.
2. Determine what trends are emerging in Africa.
3. Understand the obstacles that face online engineering education in developing countries.
4. Try to predict the future trends in online engineering education in Africa.

5. Provide ideas which may improve online engineering education.

1.6 Research Questions and Sub-Questions

The main research question is:

What trends are emerging in online engineering education in developing countries?

The sub-questions of this study are as follows:

1. To what extent are Bourne, Harris and Mayadas' (2005) expected trends regarding online engineering education actually occurring?
 - a. What trends are occurring?
 - b. What trends are not occurring?
2. What new trends can be identified that were not included in the 2005 Bourne, Harris and Mayadas article?
3. Why is the above happening?

In order to assess the trends in online learning in engineering science, the researcher applied these questions to each hypothesis of the research as shown in table (1-1) below.

1.7 Research Hypotheses

The hypotheses of this study were developed from Bourne, Harris, and Mayadas (2005, p.36) and are as follow:

1. Online methods in engineering education increase the breadth and scale of engineering education and extend the reach of institutions and the delivery of education to broader audiences in South Africa.
2. Specialty areas leverage expertise among institutions, thus driving down the cost of replicating facilities at multiple institutions.
3. The quality of engineering education output improves through collaboration among institutions. In addition, online methodologies enable collaboration.
4. Materials for engineering education can be utilized across institutions, thus increasing quality and driving down costs. Analogous to books that reach multiple institutions, simulations, computer-based training materials, and course management systems can also be developed in collaboration.

5. Engineering education offered in a blended format, ranging from all-online to all-classroom instruction, is on the increase.
6. Students and faculty will both demand the opportunity to teach and learn online.
7. New trends and technologies will emerge in online methods in engineering education.

Table 0.1 Hypotheses Relating to the Sub-questions

	Research Hypotheses	Research Sub-Questions		
		1	2	3
1	Online methods in engineering education increase the breadth and scale of engineering education and extend the reach of institutions and the delivery of education to broader audiences.	✓		✓
2	Specialty areas leverage expertise among institutions, thus driving down the cost of replicating facilities at multiple institutions.	✓		✓
3	The quality of engineering education output will improve through collaboration among institutions. In addition, online methodologies enable collaboration.	✓	✓	✓
4	Materials for engineering education will be utilized across institutions, thus increasing quality and driving down costs. Analogous to books that reach multiple institutions, simulations, computer-based training materials, and course management systems can also be developed in collaboration.	✓		✓
5	Engineering education will be offered in a blended format, ranging from all-online to all-classroom instruction, on an increasing basis.	✓	✓	✓

6	Students and faculty will both demand the opportunity to teach and learn o-line.	✓	✓
7	New trends and technologies will emerge in online methods in engineering education.	✓	✓

1.8 Delimitation and Limitations of the Study

As a limit on location, this research was carried out at two South African universities:

- The University of Cape Town (UCT); and
- The Cape Peninsula University of Technology in Cape Town (CPUT).

This was decided upon due to the institutions' experience in teaching and learning in engineering science using online and blended methodologies. The research was restricted to mechanical, electrical, civil, and chemical engineering departments since these engineering specializations are the more commonly offered in universities, and can thus be used as a basis for other engineering fields.

The study took place in the 2010 and 2011 academic years, drawing on the academic calendar of these universities.

The researcher conducted individual interviews with experts in e-learning and IT support, and disseminated questionnaires to lecturers and students; the questions were focused on online learning as well as blended methods in the field of engineering education.

1.9 Preliminary Studies (Pilot Tests)

There was no formal pilot test for this study. However, a literature review was used to refine the research hypotheses and to explore any expected trends in online learning. Additionally, the researcher needed to know specific details regarding the research population and participants, including participants' historical backgrounds and experiences regarding online educational methods. This enabled the researcher to refine and develop his research instruments and questions. Questionnaires and interview questions have been revised and checked for content validity with other researchers, participants and specialists in the field.

1.10 Importance and Significance of the Study

The significance of this research emerges from the importance of online learning itself. Educators and instructors of today rely on online methods and web-based learning to solve problems such as staff shortages in colleges and schools and shortages of instructional tools and supported media, especially in third world countries. Additionally, the lack of documentation of online learning in engineering education in Africa adds to the significance of this research.

It is the intention of this research to present a detailed description of the situation of online learning and teaching in engineering education, as well as answer questions concerning the value of internet and online teaching and learning methods. It is expected that the findings of this research will engender a wide interest among educators and e-learning experts and be of use to:

- Engineering teachers, lecturers and students, especially those who are already teaching and learning online or those who would like to do so.
- Principals, heads of department, chancellors, stakeholders and policymakers of universities, institutions and schools.
Instructional designers, learning resource managers and learning design centre managers.

1.11 Conceptual Framework

1.11.1 Online learning

The word 'online' has historical links to the telegraph when messages were sent through a machine via a special telephone line rather than produced by hand (Salmon, 2000, p. 3).

The more modern meaning of 'online' usually refers to using a computer linked to the internet via a telephone line (University of South Australia, 2004). Thus, online learning means teaching courses entirely - or partly - online making use of a variety of technological elements (University of South Australia, 2004).

When people learn online they use a range of technologies which mainly involve the internet. The internet enables us to communicate one-to-one (for example, the

facilitator communicates via email to a student about their assignment) or one-to-many (for example a student posts a question to the course discussion group). Other technological capabilities might also be used in online teaching.

This study focused on many of these capabilities, such as: chat, list serves, instant messaging, video conferencing and audio conferencing.

1.11.2 Engineering education

Word IQ (2010) defines engineering as “the application of science to the needs of humanity. This is accomplished through knowledge, mathematics, and practical experience applied to the design of useful objects or processes. Professional practitioners of engineering are called engineers.”

Douglas, Iverson and Kalyandurg (2004); and Engineering education (2012) defined engineering education as “the activity of teaching knowledge and principles related to the professional practice of engineering. It includes the initial education for becoming an engineer and any advanced education and specialization that follow”.

In this study, engineering education is the centre of concern and the participants of the study are drawn from engineering fields, as this study aimed to document trends in online engineering education from managing, learning and teaching perspectives.

1.11.3 Information and Communication Technologies (ICTs)

The term ICT (Information and Communication Technology) refers to computers, computer infrastructure and any associated technologies, including software, hardware, and internet connectivity (Rahimi, 2008; Tech Terms, 2005). ICT in education can be broadly categorized in the following ways as (Wikipedia, 2011):

- ICT as a subject (i.e., computer studies)
- ICT as a tool to support traditional subjects (i.e., computer-based learning, presentation, research)
- ICT as an administrative tool (i.e., education management information systems/EMIS)
- ICT as a medium of knowledge exchange

This study focused on the third aspect, which is using ICT as tools for learning and teaching with concentration on online methods and online technologies.

1.11.4 E-learning system

The e-learning system is a comprehensive software package that supports "courses that depend on the World Wide Web (WWW) for some combination of delivery, testing, simulation, discussion, or other significant aspect" (Robson, 1999, p. 271).

Zaitseva and Bule (2006) presented a three-level architecture that can be used for e-learning systems:

- I. A kernel of a system, which takes data from knowledge and a database.
- II. Subsystems or agents.
- III. Modules which realize function of definite agent.

Many South African universities use the learning management system as it is one of the most common e-learning systems. In order to address the effectiveness of using learning management systems in different universities, this study explored the limitations of using e-learning systems in South African universities.

1.12 Overview of Thesis Chapters

This thesis has five chapters (figure 5-1). **Chapter one** –introduction- describes the research problem, rationale and purposes of the study. It also serves to present the questions and hypotheses of the study. In addition, chapter one shows the significance and importance of the study as well as explaining the limitation of the research. Additionally, chapter one contains the conceptual framework which gives a brief definition of the research concepts and application of each concept in this study.

Chapter two –literature review- documents and discusses previous studies and findings that relate to this study. Chapter two starts with a general introduction, followed by a review of literature in engineering fields, the importance of and the need for engineering education, the role of ICT in engineering education and the application of online methods in engineering education. Furthermore, it examines the current and emerging trends in online learning; specifically online engineering education. This chapter ends with a review of the theoretical framework which informs this thesis,

namely the activity theory (Engeström 1998) and the theory of diffusion of innovation (Rogers 1995).

Chapter three -research design and methodology-justifies the use of mixed methods and the philosophical paradigm behind this method. The chapter explains in details the research strategy including data collection methods and sources (population and samples), data analysis and interpretation methods. Furthermore, it tackles the validity, reliability and generalisability issues of the study, and ends with ethical considerations for the study.

Chapter four -data analysis and interpretation–provides and describes the analysis of both quantitative and qualitative data collected from the faculties of engineering of two South African universities using questionnaires and interview methods. In addition, the chapter summarizes the research findings and presents full discussion of the results compared with other previous studies as well as the research hypotheses.

Chapter five-conclusion and recommendations -the chapter presents conclusion drawn from the research and discusses limitations and recommendations for additional research.

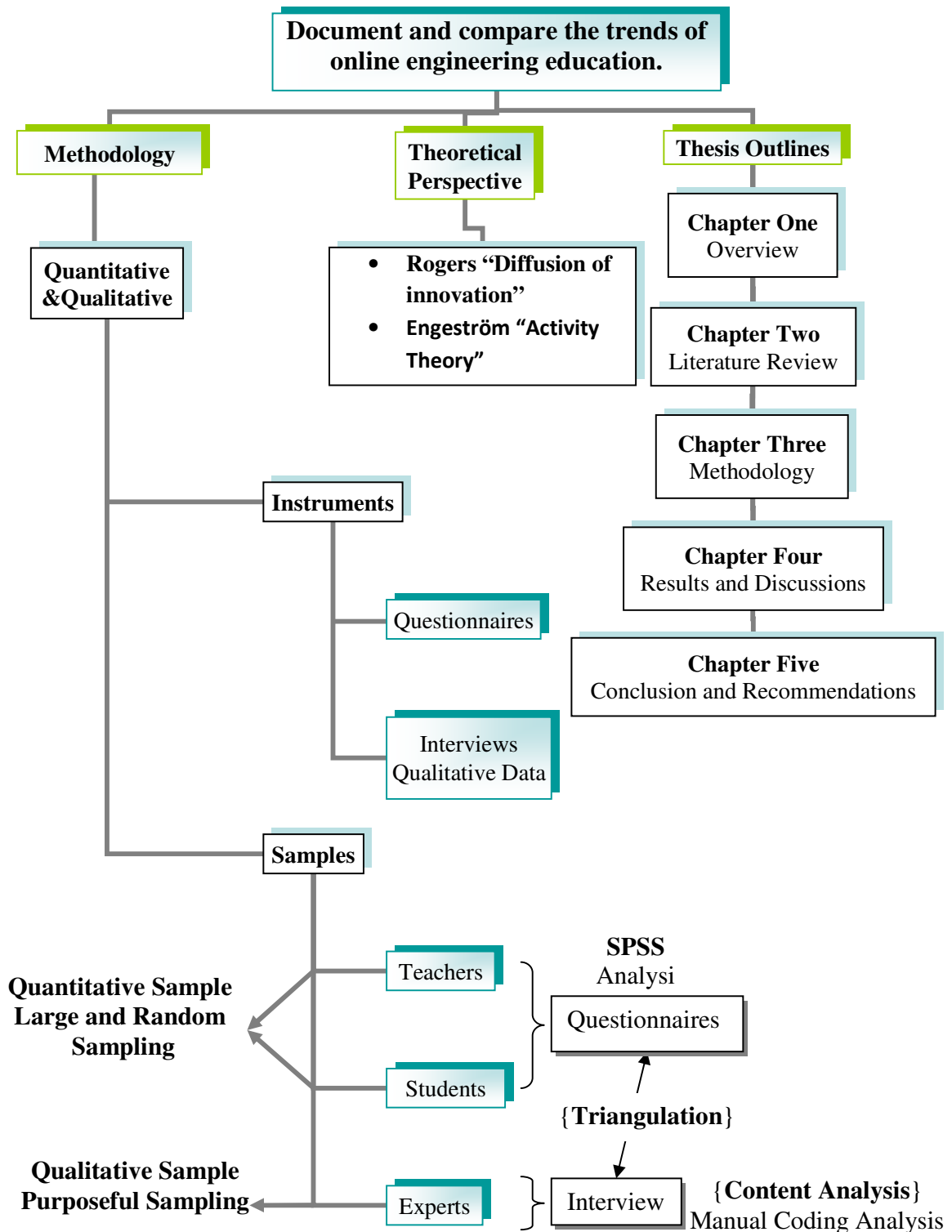


Figure 0.1 Research Framework

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