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Improving learning outcomes within a developing maritime nation lacking practical resources through the introduction of classroom technology : a case study at a South African University of Technology

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A case study at a South African University of Technology

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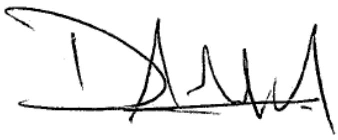
DECLARATION

This thesis contains no material that has been accepted for the award of any other degree or diploma at a university. To the best of my knowledge and belief, this thesis contains no material previously published by any other person except where due acknowledgement has been made.

Signature: 

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ABSTRACT

This study primarily explores whether or not the use of emerging technologies can be used to counter a lack of available resources in developing countries. The research takes the form of a case study conducted over three successive semesters at a South African University of Technology maritime campus, with the subjects being the Marine Engineering students at a senior level. The study makes extensive use of concept mapping to introduce digital syllabi according to scaffold learning principles, and thereafter to implement a range of selected learning methods based on prominent learning theories to address the needs of the students, as identified by the surveyed data received.

Throughout the eighteen-month classroom case study, an action research method was employed to sequentially evaluate the outcomes at each phase, and amend the devised CBT program in line with addressing the research question posed. It was the intention to ascertain if any noticeable changes were evident with regards to the development of critical thinking skills on the part of the students, which would indicate a higher level of learning. The development of critical thinking skills is in line with the desire of the South African government to develop of a skills-based economy for the country, away from an historical past whereby the following of a system was often viewed above the need for critical thinking.

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LIST OF ABBREVIATIONS

2EO	Second Engineering Officer
APC	Academic Planning Committee
BRM	Bridge Resource Management
CBL	Case-based Learning
CBR	Case-based Reasoning
CBT	Computer-based Training
CoC	Certificate of Competency
CEO	Chief Engineering Officer
CHE	Council of Higher Education
CLT	Cognitive Load Theory
Cmap	Concept Mapping
CPUT	Cape Peninsula University of Technology
CPUT/UCT/WITS	Cape Peninsula University of Technology, University of Cape Town, University of the Witwatersrand
DHET	Department of Higher Education and Training
DMS	Department of Maritime Studies
DUT	Durban University of Technology
EBL	Enquiry based learning
ECSA	Engineering Council of South Africa
EOW	Engineering Officer of the Watch
GBL	Group-based Learning
HEQF	Higher Education Qualifications Framework
HND	Higher National Diploma
HTML	Hypertext Markup Language
IBL	Inquiry based learning
IHMC	Institute of Human and Machine Cognition
IMO	International Maritime Organisation
IMT	Institute for Maritime Technology
IT	Information Technology
KMS	Knowledge management System

LAN	Local Area Network
LMS	Learning management system
LSI	Learning Style Inventory
MAS	Marks Administration System
MET	Maritime Education and Training
NCP	National Cadet Program
ND	National Diploma
NMMU	Nelson Mandela Metropolitan University
NQF	National Qualifications Framework
OBE	Outcomes Based Education
PBL	Problem-based Learning
PDF	Portable Document Format
RUCST	Regent University College of Science and Technology
SAIMENA	South African Institute of Marine Engineers and Naval Architects
SAIMI	South African International Maritime Institute
SAMSA	South African Maritime Safety Authority
SAMTRA	South African Maritime Training Academy
SANDF	South African National Defense Force
SAQA	South African Qualifications Authority
SAR	Systematic Action Research
SMA	Singapore Maritime Academy
SMBM	School of Maritime Business and Management (Dokuz Eylul University)
SOFA	Statistics Open For All (open source statistics computer package)
STCW	Standards of Training, Certification and Watchkeeping for Seafarers
TVET	Technical Vocational Education and Training
UCSC	University of Colombo School of Computing
UNISA	University of South Africa
UOT	University of Technology
WMU	World Maritime University

CHAPTER 1

INTRODUCTION

Introduction

South Africa is an emerging maritime nation that is in the process of reversing a declining maritime industry in order to create employment, as well as to commercially exploit the resources available to a country with an extensive coastline. In order for those within the South African maritime industry to embrace this challenge, it is essential that the skills base be developed in line with rising international standards. This study looks at the outcomes that a change in curriculum delivery and tuition methods at a South African University of Technology (UOT) maritime campus, has on the development and improvement of Marine Engineering education at the campus.

Before conducting a review of maritime education and training (MET) in South Africa in general, it is prudent to look at the quality of the country's secondary schooling system, and the impact that this has on students feeding into the higher education system.

1.1 Secondary school education in South Africa

As a developing nation, South Africa faces certain key challenges with regards to its education system, primarily in terms of the perceived quality of education. As a result of the country having a divisive past (due to the apartheid system that previously existed from 1948 to 1994), many school-going students were previously disadvantaged in terms of the educational opportunities that were available to them at the time. With the advent of democracy in 1994, the education system was amended to accommodate students from all backgrounds and ethnic groups. However, after decades of segregation, and through being exposed to a low-quality education system

(Bantu education)[1] many previously disadvantaged groups were behind in terms of their academic qualifications. After 1994, the quality of education in certain schools and the relevance of what was being taught was brought into question.

Prior to 1997 the traditional method of school tuition in South Africa was based on an educator-centered approach (Engelbrecht & Harding, 2008). At the time, the Department of Education believed that many learners were not encouraged to develop the critical-thinking or problem-solving skills that were required of a skills-based economy (Mseleku, 2001). This formed the reasoning for the implementation of an outcomes-based curriculum[2] throughout South African Schools.

The outcomes-based education system (OBE) that was introduced into South African schools was implemented progressively from 1998 onwards, throughout the various school grades. Within an OBE environment, the students are required to work together to pose questions, from which they arrive at conclusions; and then progress further to discuss the validity of the solutions they have derived (Lichakane, 2005).

In 2008, the first group of students to successfully complete the OBE model of education (through from the start of their schooling up until Grade 12) finalised their studies within this revised curriculum. OBE has, however, had many critics who have divided opinions with regards to its viability as an education model for South African use. There have been concerns voiced at tertiary level, particularly with mathematics, that learners[3] are not as prepared for higher institutional learning as their predecessors were (Engelbrecht & Harding, 2008). In this regard, however, Mouton, Louw & Strydom (2012) believe that in order to understand the true effect of education in South Africa, recognition needs to be given to the various demographical influences that exist within the country. As South Africa is demarcated into nine provinces, each with their own Legislature, Premier and Provincial Members of Executive Councils, differences in terms of the availability of resources exist within and between the respective regions. In certain of these provinces, the many socio-economic problems

[1] Under the South African apartheid system, Bantu education was the official system of education for black South Africans.

[2] Outcome-Based Education means clearly focusing and organizing everything in an educational system around what is essential for all students to be able to do successfully at the end of their learning experiences. This means starting with a clear picture of what is important for students to be able to do, then organizing the curriculum, instruction, and assessment to make sure this learning ultimately happens (Spady, 1994).

[3] The terms 'learners' and 'students' are used interchangeably.

associated with that particular region can negatively impact on the learners' right to a decent education.

These social challenges have been ever present within the South African educational landscape for decades, with the maritime education sector being no different from other spheres of education. Ruggunan (2005) believes that the fragmented and multi-faceted state of seafarer training currently in place in South Africa is directly attributable to the apartheid-based education systems that were previously in place. The exclusion of non-white ethnic groups during the era of segregation has placed these groups at a distinct disadvantage in terms of the resources available to them. A governmental white paper promulgated in 1996 by the Department of Transport, was aimed towards growing the skills base within the maritime sector, in order to actively address these critical challenges.

In 2013, OBE was officially dispensed with as an education model at secondary schools in South Africa, as a result of the poor academic outcomes attributable to the system. The disruption that these changes caused to the education system and the people involved, left many within the country to feel that this was a period best left forgotten. The failure of OBE as a model of education, and the poor state of the South African education system in general as a result of these disruptions, have done little to bridge the divide between the different ethnic groups within the country. In 2015, South Africa ranked 138 out of 140 countries in terms of the quality of the country's secondary education system, and was stated as being the worst performing education system for mathematics and science out of the group surveyed[4].

In terms of the impact that this period has had on the higher education institutions in South Africa, including the MET institutions, challenges are being encountered due to many of the students being poorly equipped academically upon leaving school. As shipping is a global business, questions need to be asked as to the marketability of South Africa's seagoing cadets, when they may well be perceived to be poorly equipped academically.

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[4] World Economic Forum Executive Opinion Survey: Date of data collection or release: 1st September 2015; www.weforum.org/gcr

The existing difficulties facing institutions of higher learning are compounded further when students are poorly equipped academically, as it becomes the task of these institutions to build upon the knowledge base that these learners have acquired at secondary school level. In this way, failings within the education system at secondary school level are passed further up the line to become a challenge for the higher education institutions to deal with. In many sectors, including the maritime sector, it becomes difficult to equip students who have such poor academic foundations with the necessary skills that the workplace demands of a developing economy.

1.2 Maritime education and training in South Africa and Africa

After many years of decline, which ultimately resulted in the position whereby the country had no commercial ships on the nation's shipping register, the South African government has started to prioritise the growth of the maritime sector. With a vast coastline bordering the country on three sides, the South African President has identified the ocean economy as a source of untapped potential for the region[5] (within the Operation Phakisa initiative), both in terms of employment opportunities and the management of the regional resources. It is the intention of government to develop the maritime infrastructure and knowledge base that exists in order to tap into and further develop capacity, in order to exploit these available resources.

Part of this initiative required that the current skills level within the maritime sector be increased in order to facilitate the future growth of the sector. In 2013, the first ever group of South African students started studying at WMU in Malmö, Sweden, through an initiative instigated by the South African Maritime Safety Authority (SAMSA), funded by the Department of Higher Education and Training (DHET), to develop the maritime sector in South Africa.

The Cape Peninsula University of Technology (CPUT) in Cape Town, South Africa (where this study has taken place), is currently one of the two UOT's in South Africa where maritime studies are conducted towards seafarer certificates of competency (CoC) attainment. The CPUT Department of Maritime Studies (DMS) serves as a hub for the Southern African region, attracting student groups from very diverse

[5] As described in the Operation Phakisa initiative as unlocking the economic potential of South Africa's oceans to contribute 170 billion rand to the GDP by 2023 from 54 billion rand in 2010 (President J. Zuma, 2014)

backgrounds and cultures within South Africa, as well as many students from the neighbouring maritime countries (i.e. Namibia, Angola, Kenya and Mauritius). The CPUT Maritime Studies and Survival Centre campus provides education and training for seafarers from Able Seaman (Engine) ratings through to Chief Engineer. Currently the CPUT DMS administer Marine Engineering courses based on the requirements of the SAMSA and the International Maritime Organisation (IMO) codes that govern the standards of MET, in accordance with the Manila 2010 amendments.

South Africa enjoys white-list status as a maritime nation, therefore, maritime education is offered in line with the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW 1978) code, which was devised to ensure that minimum standards with regards to seafarer competence were complied with. This internationally agreed convention was revised in 2006, resulting in what is known as the Manila 2010 amendments to the STCW code. These amendments entered into force as of January 2012. Marine Engineering syllabi have recently been revised at CPUT in line with these new amendments, and are in the process of being updated to incorporate recent technological advancements in line with the mandated code requirements.

Seafarer education is offered at the CPUT DMS in both a classroom environment (theoretical classroom tuition) as well as the practical components of computer simulation and survival techniques at the Survival Centre. Within the framework of the Marine Engineering program, the use of simulators is minimal largely as a result of (a) the limited timeframe available in which to complete the theoretical component of the course and (b) the number of students admitted being too large for simulation training. While the use of engineering simulators has provided MET institutions with new methods of being able to restructure Marine Engineering programs, there are certain drawbacks associated with the use of simulators as an educational tool (Cwilewicz, Tomczak & Pudlowski, 2004). Simulators remain heavily focused on teaching practical competence and understanding of operating principles, doing little in way of technical preparation towards Marine Engineering syllabus (and CoC) examinable theory. Within South African MET, simulator use gets prioritised within a separate Bridge Resource Management (BRM) course run by the South African Maritime Training Academy (SAMTRA).

Currently the CPUT DMS offers theoretical tuition in the form of six-month semesters: S1 and S2 for the Engineering Officer of the Watch (EOW) levels and S3 and S4 for the management level officers. Recently the CPUT DMS has proposed a new framework for maritime qualifications within the South African Higher Education Qualifications Framework (HEQF), to upscale from the current National Diploma offerings. Initially envisaged to start in 2013 (Snyders, 2011), the DMS intends to offer Bachelor's Degrees in Nautical Science and Marine Engineering, which have recently been rescheduled to commence in 2018. Both programmes have been approved by CPUT's Academic Planning Committee (APC), CPUT Senate and the DHET, and have recently been cleared by the Council of Higher Education (CHE) and the South African Qualifications Authority (SAQA). In addition to this, the DHET has approved higher certificates and advanced certificates in Maritime Studies and Marine Engineering, which can be offered external to CPUT.

NQF Level	NQF Band	HEQF Type of Qualification (DHET)				Equivalent $STCW_{95}$, as amended, Qualifications aligned to HEQF (NDoT / SAMSA)	
10	**HE** Post-graduate	**Doctoral Degree**					
9		**Masters Degree**					
8		Professional Bachelor's Degree Minimum NSC Rating 4 (50-59%)	**Bachelor Honours Degree**	Post-graduate Diploma	*Post-graduate Diploma*	Master Unlimited CoC ***(min 24 months sea service)***	Chief Eng CoC ***(min 24 months sea service)***
7	**HE** Under-graduate		**Bachelor's Degree** Minimum NSC Rating 4 (50-59%)	*+ 12 months work-based learning*	*Advanced Diploma*	Chief Mate CoC ***(min 12 months sea service)***	2nd Eng CoC ***(min 12 months sea service)***
6				Current National Diploma *(S1 to S4)* Minimum NSC Rating 3 (40-49%)	Advanced Certificate	Semester 3 + Semester 4 *(Acad Chief Mate & Master)*	Semester 4 *(Acad Chief Eng)* Semester 3 *(Acad 2nd Eng)*
5						Deck Officer CoC ***(min 12 months sea service)***	Engineer Officer CoC ***(min 12 months sea service)***
					Higher Certificate Minimum NSC Rating 3 (40-49%)	Semester 1+Semester 2 *(Acad Deck Officer CoC)*	Semester 1+Semester 2 *(Acad Engineer Officer CoC)*
4	**FET**	- National Senior Cert (NSC) - National Certificate Vocational (NCV)					
3	**GET**	General Education and Training Certificate (GETC): ***Senior Phase**, Grades 7-9; **Intermediate Phase**, Grades 4-6 & **Foundation Phase**, Grades 1-3*					
2							
1							

Figure 1: Table - South African National Qualifications Framework (NQF) levels and associated qualifications table (Snyders, 2011).

The curriculation of the BSc Marine Engineering degree program to be offered at the CPUT DMS is aimed at accommodating students who wish to pursue a career at sea as the primary objective. However, it is the intention to include sufficient diversification in order to accommodate those students who seek employment within other maritime disciplines. This is to allow for students who wish to branch out into other sectors of the maritime industry to be able do so, either from the outset or at a later stage of their seagoing careers. Students with a Masters CoC or Chief Engineering Officer CoC will be eligible to slot into the postgraduate maritime program at Honours level once the BSc Honours program is in place at a later date.

Further requirements of the proposed curriculum changes include the need to accommodate those students who are half way through their National Diploma (ND) program, yet are currently serving the industry at sea, and plan to complete their studies at a later date. These students will be accommodated as best possible within the new curriculum. As the seagoing component is vital for students to gain practical experience within the industry, it is important that the lack of exposure within the proposed degree program be addressed, or compensated for, if the students are to gain a meaningful understanding of shipboard practices.

1.3 Challenges facing maritime education and training in South Africa

Maritime education in South Africa moved from being offered at an independent maritime college (General Botha), to becoming part of the Cape Technikon Mechanical Engineering department. The Cape Technikon was later to merge with the Peninsula Technikon to form CPUT when changes were made to the higher education landscape post 1994. This resulted in a shift of focus from primarily serving the needs of the industry (seagoing students) to a model that catered for all students that were interested in pursuing a career in the maritime industry. As a result of this, the Marine Engineering classes (at all levels) contain a mix of students that have prior seagoing experience, and those that do not. Whilst the ideal model would be to split the classes into two groups (based on experience), a lack of resources (both in terms of available classrooms and lecturing staff) do not allow for this.

In this regard, and due to the fact that many of the students that are admitted are often ill-equipped academically to cope with study at a higher education level, there are two primary challenges with regards to the delivery of a Marine Engineering curriculum at the CPUT DMS.

These primary challenges can be described as follows:

Challenge No. 1: Seafarer experience levels

As a result of the small size of the South African maritime industry, it is often the case that many of the students who attend class were unable to obtain adequate shipboard experience before commencing their theoretical studies at the CPUT DMS. This particular challenge is likely to escalate once the degree program is in force at the CPUT DMS, as the likely seagoing experience levels of the students within the Marine Engineering stream will likely decline further (as a result of the length and cost of the program). It is anticipated that the majority of future students will be school leavers and bursary students as opposed to those students actively serving the industry at sea, due to the requirement for three years of continuous study.

The primary reasons for the current lack of practical experience (in general) among the students can be detailed as follows:

(1) While sea time is a necessary requirement before any STCW CoC assessments are undertaken at SAMSA, it is not a requirement for entrance to maritime studies at higher education institutions in South Africa. As maritime education at the higher levels is only offered at one of the two UOT's at present, the admission requirements disregard prior industry experience or previous certification obtained, in preference for pure prior academic performance. The reasoning behind this is that the UOT's treat Marine Engineering the same as other engineering disciplines, where no practical experience is required for admission.

    As a result of this institutional stance, it is possible to attend classes up to Chief Engineer's level without any sea time being recorded. A survey conducted among the 2015 first semester student intake (survey 1)[6] showed that 60% of the student intake enrolled for study at the first management level (S3: Second Engineering Officers), had obtained no prior seagoing experience at the time of admission. This places undue strain on those students without any seagoing

[6] Survey 1 is the primary information survey that is conducted at the start of each phase of this study.

experience, workshop experience or having done any prior maritime courses, as they often cannot envisage shipboard equipment in the manner that more experienced students can. Similarly, a certain element of resentment exists on the part of those students who have accrued sea time, as to why the most basic concepts are still addressed at a management level (which is a necessity with unfamiliar students).

(2) Due to South Africa's location on the globe, South African seafarers generally travel extensive distances to join vessels for their tours of duty, often travelling to their designated vessel on a limited duration transit visa. As a result of this, many international companies prefer to place the South African seafarers on vessels out at sea, as opposed to placing them on vessels under repair (i.e. dry dock). Many of the senior students in the maritime study stream have never attended a dry-docking of a vessel, yet this forms a significant part of the theoretical studies at the CPUT DMS and is examinable at the time of STCW CoC assessments.

(3) Marine engineering is a subject that covers a multitude of vessel classes and machinery types. It is therefore natural that experience gained within the industry, will have been gained on certain types of vessels, meaning that a lot of the subject matter (steam propulsion turbines for example), is completely foreign to the majority of the students. One often cited concern on the part of the students is the lack of practical ship visits that are conducted during the course of the semester, as they feel that this could help them to familiarise themselves with unfamiliar systems and vessel classes. In principle, the CPUT DMS is in agreement with this, however it becomes extremely difficult to co-ordinate in practice with so few vessels docking at the port of Cape Town. Additionally, with class sizes that are in excess of the IMO recommended guidelines (24 students), it becomes a time consuming process if the students are split into groups.

Of particular concern to the maritime industry at present, is the limited numbers of South African students that are able to secure training berths upon vessels at sea in order to follow up on their initial theoretical studies[7]. The adoption of the retired SA Agulhas Antarctic research vessel as a training vessel by SAMSA had gone a way

[7] South African Institute of Marine Engineers and Naval Architecture keynote address feedback received on the 29th August 2014.

towards alleviating this problem to some extent, however this initiative was relatively short lived as a change of vessel management resulted in this program stalling in 2015. Future use of the vessel and its effectiveness as a training vessel under the control of the newly formed South African International Maritime Institute (SAIMI) is still to be clarified.

For the purpose of this study, the definition of experience[8] adopted is as follows: "the process of gaining knowledge or skill over a period of time through seeing and doing things rather than through studying".

Challenge No. 2: English language skills

A second challenge results from the fact that South Africa as a country has eleven official languages. As the CPUT DMS serves as a hub for the Southern African region, and thus accepts many more diverse cultures, the language diversity within the class can become problematic from an English language perspective.

For many students, English is their second, third or fourth language[9]. It is very often the case that questions are misinterpreted, or that a vast amount of learning that takes place on the part of the student is done by rote learning, through not being fully conversant with the wording involved.

1.4 Purpose of the study

Research aims

The aim of this research is to investigate whether or not the current model of Marine Engineering tuition offered at the CPUT DMS is in the best interests of the Marine Engineering students who enroll to study at the institution. This comes about largely as a result of the advancements made in available technologies, and the current lack of industry exposure (in general) on the part of the students. Using the results obtained from data collected, it is the intention to design and develop a computer-based training model (CBT) of education that is able to use computer imagery and technology to positively address the primary shortcomings, within the current environment.

[8] Oxford Advanced Learners Dictionary definition, Oxford University Press, 1995.
[9] Data retrieved from the initial round of surveys conducted (survey 1).

Furthermore, it is the intention to introduce a range of selected learning methods in line with selected learning theories, aimed at addressing the identifiable shortcomings of the current model.

The objective of this study is to test the effectiveness of the use of this developed technology, and the effectiveness of the introduction of the developed learning methods, in terms of student outcomes; from both qualitative and quantitative analyses that have been conducted.

(a) Testing the impact on students with limited industry experience

As stated, one of the main challenges facing the South African maritime industry in terms of higher education is the inability of the industry to find placement for students at sea, before or after their initial round of studies. This is due to the small size of the South African maritime industry, and as a result of this, the limited number of available berths offered by the shipping companies.

This means that many first year Marine Engineering students get placed in the management classes of Second Engineering Officer (S3) and Chief Engineering Officer (S4) to continue their studies the following year, despite not having accumulated any sea time or practical industry experience at the operations level.

It is the intention of this study to ascertain to what degree, if any, classroom technology and the introduction of the chosen learning methods can make up for this lack of prior industry exposure on the part of the students. The aim is to place a more visual and familiar 'face' to the course through introducing a greater amount of visual media and case-study material, in order to accommodate those students who have never seen many of the systems being studied.

(b) Testing the impact on students with limited English language skills

A further aim of this study is to investigate to what extent a collaborative approach to learning can aid in fostering an inclusive environment within the classroom for those with lesser English language skills.

One way to overcome language related barriers and to foster a deeper form of understanding, is to make optimum use of available technologies in conjunction with peer-to-peer learning practices. With peer-to-peer learning, students can learn from each other and aid one another in the attainment of the course objectives.

Research question

To address these concerns, the following research question has been posed which form the basis of this study, namely:

> *Could technology be used to counter a lack of available resources, in order to improve the academic outcomes of Marine Engineering students in South Africa?*

Each of the three month semester periods that form the data collection period of this study looks at the impact that different design elements and learning methods add, in terms of adding value to the academic outcomes. The data collected from each cohort of students from successive semesters has been used to answer three sub-questions under the umbrella of the primary research question. These three sub-questions are listed as follows:

(1) By adopting a purely paper-based method of tuition as opposed to the purely computer-based method of tuition that previously existed, would there be any notable improvements in student learning outcomes among the research participants?

(2) If the CBT model were tailored to work in conjunction with existing paper-based literature in order to enhance the understandability of the texts, would there be any notable change in terms of academic outcomes among the research participants?

(3) Would incorporating learning methods based on prominent learning theories, that have been specifically developed in order to address the identifiable challenges that exist, have any significant impact in terms of learning outcomes among the research participants?

This study intends to focus on the more senior group of Marine Engineering students (the Second and Chief Engineers), who represent the Engineering Officers at a management level. The outcome of this research is to be used to develop an adaptable CBT model of education that is able to incorporate the use of updated technologies and suitable learning methods (based on selected learning theories) to address the identifiable shortcomings that exist.

The data collection and analysis process have been completed over the course of two years (four successive semesters). The first part of the study included an initial student environmental assessment, whereby the current student circumstances and resources were taken into account in order to determine the most practical form of CBT model for adoption.

In semester two, the outcomes of a tailor made CBT model that was in use for the semester was compared to the outcomes of the previously offered paper-based syllabi. The second research question tested in this study was to ascertain the impact that this CBT model of education, used in conjunction with written literature, would have on student learning outcomes. The final phase of the study assesses the impact that two primary learning methods, namely case-based learning (CBL) and group-based learning (GBL) have on student learning outcomes. The learning methods and case studies investigate whether or not a greater exposure to onboard procedures and the understanding thereof would benefit those students with lesser experience. In addition, the group-based nature of the study was intended to determine the impact that co-operative learning[10] has on the students, as opposed to individual tuition.

Over the course of this study, and through the development and modification of the system at each phase, it was the intention to transform the original 'chalk and talk' teaching methods into a system where the lecturer becomes the facilitator of a group-orientated peer-to-peer learning process, and to test the results thereof. The retention of this CBT model will be dependent upon the outcomes of the study, and may or may not be adopted for permanent use after the study has been concluded.

1.5 Intended academic and scientific contribution

This study makes extensive use of concept maps pioneered by Joseph Novak[11] who originally developed the technique as a means of representing knowledge. The

[10] Cooperative learning is a successful teaching strategy in which small teams, each with students of different levels of ability, use a variety of learning activities to improve their understanding of a subject (Education Consumer Guide, 1992(1), available from: www2.ed.gov.

[11] Joseph Donald Novak (1932 -) is an American educator known for his development of concept mapping in the 1970's.

concept maps developed by Novak have their origin within the learning movement of constructivism. Novak believed that his experience in this process was supported by Vygotsky's[12] (1978) ideas on the importance of social interaction in the learning process (Novak & Canas, 2004).

This research was further inspired by the contributions of Chatterjea & Nakazawa (2008) with the development of a computer-based maritime education model that was trialed at the Singapore Maritime Academy (SMA) for a short course in Singapore, using Novakian concept maps. In order to ascertain the long-term effectiveness of the concept mapping educational model trialed in Singapore, the need for a further longitudinal study was proposed by Chatterjea & Nakazawa.

The SMA study focused on a bridging course that was developed for senior engineers, taking place in a country with one of the best academic systems globally (Singapore). In contrast, this study that was undertaken at CPUT focuses on monitoring the effectiveness of an entire CBT engineering curriculum using concept mapping (for the maritime component) for engineers (a) at all levels of competence and (b) conducted in a country with one of the poorest academic systems globally. Novak believed that the lack of available resources in developing countries (that more affluent countries have regarded as being essential) could largely be obviated by the use of emerging technologies (Novak & Canas, 2004).

<u>Academic contribution</u>

The academic contributions from this study aim to ascertain how the use of emerging technologies, that are capable of supporting Novakian concept maps in delivering Marine Engineering syllabi, are able to impact learners at the CPUT DMS who lack the resources that are available within more developed countries. To support Vygotsky's constructivist theories and Bandura's[13] social learning theories, selected prominent learning methods will be introduced. This is to focus upon the ability of an institution in a developing country to adopt a method of MET education trialed in a developed country.

[12] Lev Vygotsky (1896 – 1935) was a Soviet psychologist who introduced the concept of the zone of proximal development, often understood to refer to the way in which the acquisition of new knowledge is dependent on previous learning, as well as the availability of instruction.
[13] Albert Bandura (1925 -) is a psychologist known as the originator of social learning theory. Social learning theory is how people learn through observing others.

This study is not to be taken as a comparative study, as it is the intention that this contribution aims to identify which of the learning methods trialed, in conjunction with the CBT syllabi, offers the best vehicle to have an impact on academic outcomes for the type of student that the CPUT DMS receives. Over the course of the study, it is the intention to add the academic experiences found within a developing country such as South Africa to the work of Novak and to the findings previously noted by Chatterjea and Nakazawa in Singapore. This study aims to build upon the current knowledge base by testing the longer-term effectiveness of the model introduced at SMA on a much larger scale, and over a much longer timeframe. Whilst this study is not longitudinal in nature, it is the intention to contribute scientifically through adopting ideologies of the Singaporean model, and adapting those for introduction within a developing country (South Africa), and testing the outcomes thereof.

As mentioned, vast disparity exists between the competitiveness, available resources and student ability[14] between the two countries. It therefore became obvious early on that a different approach was required in order that the model introduced could be successfully implemented and tested for its effectiveness. In order to be able to objectively look at the outcomes and impact of a CBT model of education for maritime use in South Africa, it is prudent to view certain key indicators against those found in Singapore.

[14] World Economic Forum annual assessment in Education results (2015).

The World Economic Forum's Global Competiveness Report 2014-2015 indicates the following differences that exist between the two countries:

Global Competitiveness Index Factor (2014-2015)	Singapore	South Africa
Quality of Primary Education	3 / 144	133 / 144
Quality of Tertiary Education	4 / 144	140 / 144
Quality of Math & Science Education	1/144	144 / 144
Technological Readiness	7 / 144	66 / 144
Internet Access in Schools	6 / 144	117 / 144

Figure 2: Table - Comparison between Singapore and South African education models table (World Economic Forum Global Competitiveness Report 2014-2015)

In light of these statistics, and in the absence of any classroom computer infrastructure, the manner with which the CBT operating platform was introduced at the CPUT DMS was reliant on each student having the software loaded onto their own laptop computers, and utilising a system that made use of limited bandwidth for the transmission of data between the lecturer and the students.

VARIABLES	Singapore	South Africa
Students Partaking in the Study	Senior Marine Engineers	Limited Seagoing Exposure
Course Offering	Steam Conversion Course	Entire Marine Engineering Syllabus
Assessments	Online	Written
CBT Infrastructure	Classroom	Student Owned
Data Transmission Requirements	Classroom / Online Access Requirements	Loaded on Student Computers / Limited (Email) Transmission Requirements

Figure 3: Table - Comparison between Singapore and South African CmapTools studies

Scientific contribution

Many various academic qualifications can be done through distance learning in South Africa, apart from maritime studies, which requires classroom attendance. If successfully trialed though this study, the CPUT DMS will have a facility for running a blended-learning or distance-learning course to cater for students who are actively serving the industry offshore (should this need ever become a reality). Currently, no known system exists that allows for seafarers to study at this level whilst serving the industry at sea, as seafarers are hampered by the restrictive satellite data transmission limits imposed by their companies. Creating a CBT model of education that could circumnavigate the challenges faced by seafarers studying online courses at sea could contribute scientifically to MET education for serving Marine Engineers.

This research aims to make a telling scientific contribution to the body of knowledge that can be used to better the outcomes of MET education for Marine Engineering students at the CPUT DMS. With data collected during the course of this study, information can be compiled that can address the many challenges facing seafarer education, for both attending students and their distance-learning counterparts. The formulation of a CBT model that is able to overcome the identifiable challenges (as determined) will ensure that seagoing students who are not able to attend the mandatory three years of continuous classroom based study that is to commence in 2018, will not be disadvantaged as they continue to serve the industry offshore.

It is envisaged that this study will make a contribution towards bettering the tuition that seafarers receive in South Africa, and that it can aid future studies of a similar nature conducted in other emerging maritime nations.

Summary

In order that the developed CBT model could suitably address the needs of the students and address the identified challenges, the developed CBT platform has made extensive use of learning methods that were developed from prominent educational learning theories. In addition to these learning methods introduced, extensive use was made of assignments that allowed for the students to tailor their particular knowledge maps according to their preferred learning and thinking styles.

The design elements and learning methods that have been selected are discussed in greater detail in the chapter that follows.

CHAPTER 2

TEACHING AND LEARNING IN HIGHER EDUCATION

Introduction

The desire of the South African government to initially introduce OBE was seen as a way to prepare students for work within a skills-based economy. Central to the ideals of OBE, are the requirements for the learning forces to be learner-centered, and for the teachers to become critical, independent curriculum developers. However, as most teachers in South Africa were educated under the apartheid system, they themselves had little experience with learner-centered education or curriculum development practices (Spreen & Vally, 2010).

A 2005 finding by the Nelson Mandela Institute indicated that authoritarian teacher-centeredness was most often practiced within the majority of rural classrooms, and it was the belief that this practice does not enhance critical thinking skills (Human Sciences Research Council, Nelson Mandela Foundation, & Education Policy Consortium: South Africa, 2005). For the learning process to become learner-centered, the instruction offered needs to be tailored to support and enhance the different learning styles of the students.

2.1 Learning in Higher Education

<u>Emerging technologies</u>

The term ‘emerging technologies’ as used by Novak is used within this study to represent technical evolution within the context of the environment in which the study is conducted. Emerging technologies are technologies that can be classified as being capable of changing the status quo, and can include both new and older technologies that are still relatively undeveloped in potential. Technological evolution can represent the application of existing technologies to a new domain of application, where existing technological know-how can be implemented within a new application domain, to allow it to evolve in new directions (Adner & Levinthal, 2002).

It is believed that the process of technical evolution has had a profound effect on transforming the theories and praxes of higher education, namely the student body (Stiegler, 1998). Thus, technological evolution is responsible for a change in the way students read, and they way they think (Abblitt, 2014), and it becomes the task of higher education institutions to discover new pedagogies to incorporate these new technologies in order to enhance the learning experience of the students.

Pedagogical change

One of the primary challenges facing higher education institutions becomes ensuring that classroom learning can be translated to effective workplace skills. In order that knowledge (workplace skills) can be considered more than information (classroom learning), the curriculum may require amending, and the teaching methods should primarily become constructivist in nature.

Constructivism is a learning theory that resulted directly from the work of Jean Piaget[15]. The theory of constructivism as proposed by Piaget, states that humans cannot simply be given information, which they can immediately use and understand, but rather that the knowledge must be constructed by the individual themselves (Piaget, 1952).

In order that lecturers can encourage creativity on the part of the student, constructivist pedagogy is required to enhance the thought process through student engagement with the subject content. In this regard, higher education may need to develop those skills if the students are to actively participate in a constructivist environment (Alexander & November, 2010). This can be done through the use of learning theories that can be implemented to provide the lecturers and students at institutions of higher education with the necessary platform for the students to reconstruct knowledge (Alexander, 2004).

[15] Jean Piaget (1896 – 1980) was a Swiss developmental psychologist and philosopher known for his theories on cognitive development.

2.2 Learning theories review

Upon review of the prominent learning theories that exist, namely (a) behaviourist, (b) cognitivist, (c) humanist, (d) constructivist, (e) constructionist, (f) social-learning theory, and (g) situated learning theory, for this study constructionism and social learning have been chosen on which to model the selected learning methods. This is because these theories are deemed to closely represent the best methods of attempting to address the problems as laid out in the problem statement (chapter 1.3). The contemporary learning theory of situated learning is however one that requires further attention in order to clarify the reasoning for the choice in favour of the more traditional learning theories that exist.

Situated learning theory

Within the maritime domain, a premium is placed on practical knowledge acquisition, resulting in situated learning becoming the predominant and preferred choice of knowledge acquisition (Froholdt & Kragesand Hansen, 2012). Situated learning (initially introduced by Jean Lave[16] and Etienne Wenger[17]) is a system that promotes learning through communities of practice, and should be regarded as a pedagogical strategy as opposed to a model of learning. Within these communities, knowledge is co-constructed. As members within the community get involved and develop an identity within the community, they acquire knowledge in the process (Lave, 1991), through activities that are undertaken. In this way, situated learning brings about a relationship between what is learned in the classroom and what is required in real life situations. According to Lave (1991), often, ‘children learn best what the school does not teach’, and that in practice, structure and experience combined will generate each other.

In becoming practitioners within a community, two processes are involved. The first is that of continuation with practice, and the second the displacement of the practice associated with the ‘oldtimers’. This is especially relevant to the maritime domain where technological advancement is rapidly taking place. Within this environment, the

[16] Jean Lave (1939 -) is a social anthropologist whose theorises learning as an on-going changing practice. She has been instrumental in challenging conventional theories of learning and education.
[17] Etienne Wenger (1952 -) is an educational theorist and practitioner known for his work with Lave in developing the theory of situated cognition, and communities of practice.

‘newcomers’ learn while the ‘oldtimers’ carry out the transition that ensures the ‘newcomers’ become ‘oldtimers’ themselves (Lave & Wenger, 1991).

As situated learning centres upon the notion that the process of learning takes place within specific contexts, with the context importantly impacting the learning process, Lunce (2006) cites difficulties in that, when removed from this context, the value and relevance of the knowledge may depreciate. Proponents for situated learning argue that cognition should be considered in relation to a situation rather than being an activity in an individual’s mind (Greeno, 1989). As technology has, in many respects, altered the way that individuals learn, certain environments may be replaced through simulation and computer aids. However, Chen and Hung (2002) question the suitability of situated learning for the teaching of factual information and abstract, complex concepts, which is a requirement of Marine Engineering students.

As a result of the shortage of practical resources and simulators within the maritime sector in South Africa, greater emphasis is placed on the learning process taking place solely in a classroom environment, after which practical exposure is gained in preparation for the competency evaluation that follows for CoC attainment. As this study aims to develop and test a platform that can compensate for the resources that are lacking within the South African maritime industry, and thus aid South African Marine Engineering students, the belief is in line with Lunce’s (2006) thinking that only ‘certain’ benefits of situated learning can be introduced into the classroom environment. Within the context of this study, this primarily includes compensating for a lack of resources through developing a graphical CBT aid to make theoretical knowledge meaningful, thereby placing the knowledge in context with what is to be encountered onboard a vessel at a later date.

Owing to the fact that situational learning in the true sense is problematic within the context and environment in which this study takes place, preference for this study has been towards the more traditional learning theories. This includes social learning theory, where collaborative learning takes place through the discussion of cases within class. The preferred learning theories for this study of constructivism, constructionism and social learning are briefly explained in the passages that follow, with a view towards adopting the selected learning methods that can embrace ideals of constructionism and social learning theory.

2.2.1 Scaffold learning: Constructivism and constructionism

Constructivism

Constructivism is a cognitive learning theory that focuses on the mental processes that construct meaning. Constructivists believe that all humans have the ability to construct knowledge in their own minds through a process of discovery and through the solving of problems. The formalisation of the theory of constructivism is generally attributed to Jean Piaget, who detailed the mechanisms through which knowledge can be internalised by learners. Piaget believed that through an accommodation and assimilation process, individuals are able to construct new knowledge from their experiences (Forrester & Jantzie, 1998). According to Piaget (1964):

> '*To know an object, to know an event, is not simply to look at it and make a mental copy, or image, of it. To know an object is to act on it. To know is to modify, to transform the object, and to understand the process of this transformation, and as a consequence to understand the way the object is constructed'*.

Through this assimilation process, individuals incorporate the new experiences into an existing framework, without actually altering that framework. Constructivism is often associated with pedagogic approaches that aim to promote an active learning process, or to promote learning through doing.

Constructionism

Constructionism is a learning theory that was developed by Seymour Papert[18], which is based on Piaget's constructivism theory. Constructionism shares the same views as constructivism with regards to building knowledge structures through the progressive internalisation of actions, however, it adds that the process of building knowledge happens in a context where the learner is consciously engaged in constructing something external, or at least shareable (Papert & Harel, 1991).

[18] Seymour Papert (1928 -) is a South African mathematician, computer scientist and educator who developed constructionism as a learning theory, building on the work done by Piaget (constructivism).

In this regard, constructionism places greater focus on learning through making, with the differences between the two theories summarised as follows: (a) the role that external aids have within the theory, (b) the types of external aids in use and (c) the types of initiatives taken by the learner in the design of their own ‘objects to think with’ (Ackermann, 2009).

2.2.2 Social learning: Social constructivism and social learning theory

Social constructivism

Social constructivism is a theory that followed Piaget’s original individual constructivism theories (Powell & Kalina, 2009). Pioneered by Lev Vygotsky, social constructivism centres around the premise that one’s cognitive development is directly related to one’s social development, and that the culture we live in has a direct influence over our social and cognitive development. Vygotsky termed this difference in cognitive ability as the ‘zone of proximal development’. It is the task of the educator to identify this zone, to determine where the student is situated within this zone, and to build upon their specific level through a ‘scaffolding’ process (Forrester & Jantzie, 1998). The zone of proximal development can be defined as the distance between the actual level of development as determined by independent problem-solving means, and the level of potential development as determined through problem-solving under adult guidance or through a process of collaboration with more capable peers. It is through this process of 'scaffolding' that a learner can move beyond the limitations of physical maturation to the position whereby the actual development process starts to lag behind the learning process (Vygotsky 1978).

Within the theory of social constructivism, instructors are required to adapt to the role of facilitators as opposed to adopting a purely teaching role. Social constructivism as a theory has been strongly influenced by Vygotsky's (1978) work, which argued that knowledge is first constructed in a social context and is then appropriated by individuals. The process of sharing individual perspectives, results in a position whereby learners construct knowledge together, that they would not necessarily do alone.

Social learning theory

According to the social learning theory devised by Albert Bandura, new behavorial patterns are acquired through direct experience or through the observations of the behaviours of others (Bandura, 1971). Observers within the system transform, classify and organise the information into schemes that can be easily remembered, rather than becoming instruments that store representations of modeled events (Tudge & Winterhoff, 1993).

Bandura is not of the opinion that peer interaction is more effective than adult-student interaction (agreeing with Vygotsky but disagreeing with Piaget), placing greater importance on the competence of the model and the attitude of the student towards the model (Tudge & Winterhoff, 1993). It is important to note that Bandura advocates the fact that individuals are capable of self-regulation and self-direction, with the relationship between the student and the environment being one of mutual interaction and influence (Bandura, 1977).

Summary

Taking the basic concepts of each selected theory into account (constructionism and social learning), and formulating/selecting learning methods to work within the ideals of each of the selected theories, it is the intention to test the learning methods used in-line with Novak's scaffold principles within a concept-mapping environment.

In addition to statistical outcomes analysis being conducted, in terms of the favoured learning theories (and the selected learning methods to implement those theories), outcomes from this study are to be assessed in the following ways:

(a) The constructionist design elements of the concept-mapping platform, and the ability of the scaffold nature of the design to allow for the students to construct meaningful knowledge structures.

(b) The social learning aspect is to be assessed in terms of effectiveness with the introduction of group-based learning (GBL) and case-based learning (CBL) in the third phase of this study, given that a large portion of the student body comprises foreign students, or groups from similar backgrounds.

In order to create knowledge maps that are able to engage the students in the learning process, the different learning and thinking styles of the students requires consideration. In the section that follows, a review is conducted of the prominent learning and thinking styles with a view towards incorporating the key elements within the design of the student assignments. While a detailed outcomes of these individual items would be difficult to assess in a study of this nature, the effectiveness on tailoring the assessments to cater for the different learning and thinking styles that exist is viewed in terms of the outcomes noted due to the constructionist and social learning design elements in the paragraph above.

The formulation of the revised CBT syllabi layout used for this study has been done in a manner that attempts to appeal to the different thinking and learning style preferences of the students. These key thinking style (Sternberg)[19] and learning style (Kolb)[20] preferences are described next.

2.3 Thinking and learning styles

Another vital aspect for consideration when it comes to the comprehension of the subject material is to look at the preferred thinking and learning styles that are chosen by the students during the learning process. The quality of learning that takes place in a classroom environment is in-part due to the compatibility of the student's individual learning style to the teaching style as used by the lecturer (Gilakjani, 2012). The term 'learning style' refers to the preferred ways in which students deal with the material (i.e. orally or visually), whereas the term 'thinking style' refers to the ways in which students think about the material. In this regard, thinking styles can affect learning, but are not to be regarded as a style of learning (Sternberg & Zhang, 2005).

Sternberg's thinking style model

The understanding of a student's thinking style is important in terms of being able to alter instruction in order to enhance the learning outcomes. According to the theory of

[19] Robert Sternberg (1949 -) is an American psychologist renowned for several influential theories related to creativity, wisdom and thinking styles.
[20] David A. Kolb (1939 -) is an American educational theorist renowned in educational circles for his learning style inventory (LSI).

mental self-government[21], it is possible to understand students in terms of constructs. This includes the following: (a) function, (b) form, (c) level or (d) leaning (Sternberg & Zhang, 2005). These constructs can be explained as follows:

(a) Functions: Three functions of government are contained within the theory of mental self-government. These functions are listed as follows:

(i) 'Legislative' students prefer to decide for themselves what must be done and how to do certain tasks, rather than be told how to do the tasks. This group is more creative; preferring situations where they can plan, formulate strategies etc.

(ii) 'Executive' students prefer rules, structures and procedures within which to complete certain tasks. These students prefer to be told what must be done, and then be allowed to get stuck in to complete the task as best possible. Traditional teaching methods have generally rewarded this type of student.

(iii) 'Judicial' students prefer tasks that require analysis, comparison and evaluation. These students like assessing and commenting on the work of others, and assessing the strengths and weaknesses of the evaluated work.

(b) Forms: Four forms of government are contained within the theory of mental self-government. These form types are listed as follows:

(i) Monarchic: These students prefer tasks that focus on one specific aspect at a time, and wish to continue with that task through to completion.

[21] Using the word 'government' metaphorically, Sternberg contended that just as there are different ways of governing a society, there are different ways that people use their abilities (Zhang & Sachs, 1997).

(ii) Hierarchic: These students prefer tasks that allow for a hierarchy of goals that must be completed, and often compile lists to ensure that the hierarchical structure is complied with.

(iii) Oligarchic: These students prefer tasks that can adopt a multitude of approaches in order for the task to be completed, with a number of aspects having equal importance.

(iv) Anarchic: These students are very flexible when it comes to their studies, trying different approaches in order to complete the given tasks.

(c) Levels: Two levels of government are contained within the theory of mental self-government. These level classes are listed as follows:

(i) Local: Students that prefer a local style prefer tasks that allow them to engage with concrete and specific details associated with the task.

(ii) Global: The global style describes those students that prefer to deal with larger abstract ideas and concepts, however, these students may often lose touch with the details of the task at hand.

(d) Leanings: Two leanings of government are contained within the theory of mental self-government. These leaning classes are as follows:

(i) Conservative: The conservative student will prefer tasks that require them to observe and adhere to rigid rules and procedures.

(ii) Liberal: Students that prefer a liberal leaning have a preference for tasks that involve an element of unfamiliarity, of stepping outside the boundaries, and enjoying freedom away from the more rigid rules and procedures that the conservative style students prefer.

Kolb's learning style model

Kolb's learning style model classifies learners into two groups with regards to how they receive information (which can be via concrete experiences or through abstract conceptualisation), and two dialectically further groups as to how this information is processed (which can be via active experimentation or through reflective observation).

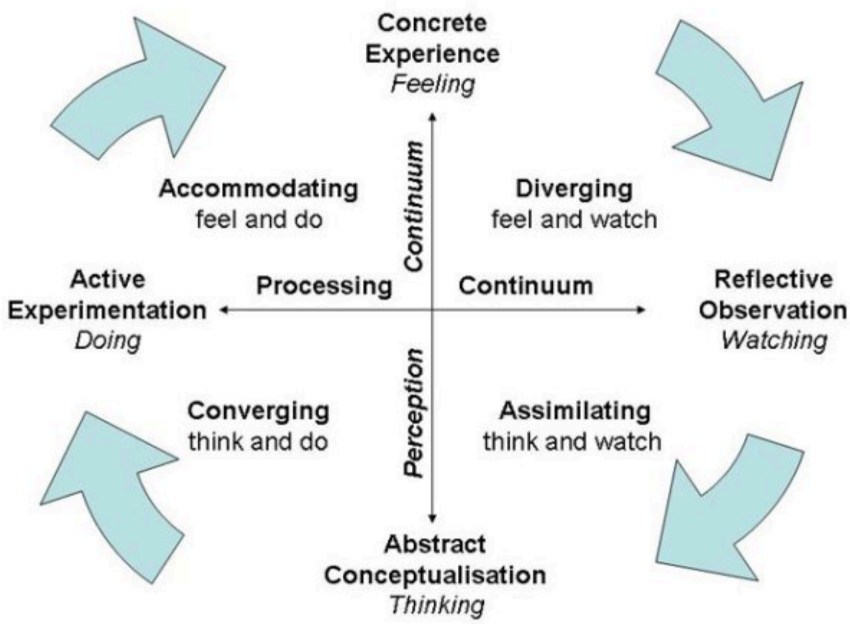

Figure 4: Kolb's (1974) Learning Style Theory (model: McLeod, 2013)

An examination of the experiential learning theory model developed by Kolb indicates that the process of learning requires abilities that are polar opposites to each other, and therefore requires that the student choose a set of learning abilities according to a specific learning situation (Kolb et al., 2001).

These groups produce four specific learning styles, best answered through the use of a preferred line of questioning, namely:

(1) Concrete, reflective learners (diverging style learners) would like to answer the question "why". In this regard, the teaching style of the lecturer should adopt a

motivational guise, in an attempt to guide the learners towards a particular solution if they are to form a meaningful connection.

(2) Abstract, reflective learners (assimilating style learners) prefer expert information from the lecturer in a logical manner, in order to address their preferred question of "what ".

(3) Abstract, active learners (converging style learners) who would like to understand the question of "how", prefer to derive solutions based on experimentation; therefore the teaching style for this group of learners should slant towards the provision of guidance and feedback.

(4) Concrete, active learners (accommodating style learners) would like to understand "what if" and to search for solutions within scenario's. This learning style is best enhanced through a teaching style that allows for a process of discovery with limited intervention on the part of the lecturer.

Kolb believes that one's career choice can shape the preferred learning style of the learner, stating that a common set of values, beliefs and professional expectations can develop habits that shape learning style preference. According to Kolb, the converging learning style is dominant among professionals within the field of technology (Kolb et al., 2001). Felder (1996) however believes that the established methods of engineering instruction cater mostly for those learners whose learning preference is towards answering the "what" line of questioning (assimilating style). In order that the teaching and learning process appeal to all of the four preferences mentioned in Kolb's model, lecturers should also explain the topic relevance (to address the "why" learners), provide practical scenario's (to cater for the "how" preference) and to encourage freedom of exploration (for those learning styles wishing to understand the "what if" aspect on the subject matter).

<u>Teaching and learning style mismatch</u>

With regards to engineering education, it has been found that the preferred learning styles of the students are very often not suitably matched to the preferred teaching styles of most engineering lecturers (Kapadia, 2008).

The first instance where mismatch of styles occurs comes about due to the fact that in general, engineering students prefer one of the two primary sense receptors for the processing of information, these being either visual (pictures, diagrams, animations etc.) or audible (sounds). It has been found that the majority of higher educational institution students favour visual means as a method of processing information, again in contrast to the verbal method of teaching that takes place at most engineering institutions. Incorporating both visual and audible elements in the teaching process reduces the mismatch, thus being able to better appeal to the preferred learning styles of the students.

Another mismatch occurs as a result of most engineering courses being conceptual rather that being purely factual in nature, leading to the information exchange process tending to favour those learners who are intuitive[22] by nature. This process is however in contrast with the majority of engineering students who have been found to be sensory[23] learners from prior studies (Kapadia, 2008). In order to be effective as a teaching style, and thus match the preferred learning styles of both the intuitive and sensory learners, the teaching style used should incorporate a mix of both factual information and theoretical principles.

It has been found that the majority of engineering students prefer inductive methods of learning, being the accumulation of knowledge borne out of the need to solve a problem, however, most of the lecturers at higher education institutions prefer deductive methods of curriculum delivery. This is primarily down to the fact that engineering curricula often start at the junior levels with the underlying concepts and fundamentals, and move towards the operational and design elements as the students progress to more senior levels. An effective path towards appealing to both learning styles is to precede the theory (deduction) with a problem statement or a review of observable criteria that the theory will clarify.

With regards to active and reflective learning styles, it is often the case that traditional engineering lectures disadvantage both of these groups, as the passive nature that is involved does not allow for the experimentation aspect of learning that active learners

[22] Intuitive: Internal stimulus, favouring insight, possibilities and hunches as data processing methods.
[23] Sensory: Students who fall into this category like to learn facts, they don't take easily to surprises and would rather solve a problem by following methodical procedures that are established.

prefer, nor do the lectures provide sufficient time for the reflective learners to theoretically digest the information received. If both active and reflective learning styles are to be accommodated through the teaching method used, periodic pauses should be introduced to allow for thought (thus affording reflective learners time to digest the theoretical aspect of the course), and problem solving activities introduced to allow for the process of experimentation for the active learner component.

When analysing the learning styles of the sequential and global learners, Felder and Brent (2004) found that much of that which is needed by a sequential learning style is being provided through the majority of engineering teaching styles. This is primarily because the material, syllabi and lectures are sequential in nature and due to the fact that the sequential learning style resembles a linear pattern, sequential learners can easily relate to this method. Sequential learners will accept information that is not completely understood, whilst global learners are reluctant to do so. As a result of this, global learners require the bigger picture to be presented or defined, before the intermediate steps that are covered within the lecture can be comprehended. To make the lectures appealing to global learners, challenges should be presented to them through the lectures that promote the seeking of alternative solutions and outside sources of information.

In summary, Felder (2010) states that learning styles should not be regarded as either-or categories, but rather as preferences that are mild, moderate or strong. The optimal teaching style of the lecturer should strike a balance, not necessarily of equal proportions, between the available styles. Acquainting students with their preferred learning styles may enhance their existing strengths, and at the same time, alert them to learning needs that unless addressed, could pose certain academic difficulties for them. In order to ensure that a deeper level of understanding can be determinable over the course of this study, it is important to view the effectiveness of these selected methods according to the classifications laid out within Bloom's[24] taxonomy in the section that follows.

[24] Benjamin Bloom (1913 – 1999) was an American educational psychologist who made contributions to the classification of educational objectives and to the theory of mastery-learning. In 1956, Bloom devised a classification of learning objectives that has come to be known as Bloom's Taxonomy.

2.4 Blooms taxonomy review

The process of thinking within constructivist paradigms requires the use of higher-level skills, as one is required to delve deeper into the content and context of the task (Nanjappa & Grant, 2003). In this regard, in order to ensure that the material learned in the classroom can be placed in a meaningful context onboard a ship, especially in the case where much of the environment is unfamiliar with many of the students, it is important that a deeper level of understanding be achieved on the part of the students. In 1956, American psychologist Benjamin Bloom developed the original taxonomy model that categorised the human cognitive domain into a hierarchical structure that served to illustrate the levels of subject understanding. In order for subject information to be more thoroughly and deeply understood, it is necessary that each successive domain be conquered before moving on to the next level of cognitive development (Bloom, 1979).

In the original model, the lowest order skill of knowledge related to the pure recall of previously learnt material, without the requirement for actual comprehension of the subject matter. In the field of engineering, this first level knowledge recall proves insufficient in most instances. Stronger skill sets such as the comprehension and application of knowledge are required in order to review available options, and apply solutions to situational problems as they arise. Moving up the original cognitive pyramid devised by Bloom, the level of comprehension describes the lowest order of understanding of the knowledge recalled. This skill set allows the student to describe certain items, and to explain certain processes by placing the recalled knowledge into certain contexts. A deeper form of comprehension is represented by the next level of cognitive development, that of the application of the recalled knowledge. This skill set equips the student with the ability to utilise theorems and principles attained in different situations.

Higher levels of comprehension are demonstrated by the ability to deconstruct the subject matter, and recognise the operational principles involved. This is done to gain an understanding of how the components relate to each other. This occurs at the analysis phase of cognitive development. This skill set evolves into the creative synthesis component, a process of forming new concepts. In the original model, the highest level of cognitive development equips the student with the ability to judge for themselves whether certain ideals are suitable for certain scenarios, thereby making the most meaningful contribution to the development of the profession.

In 2001, Bloom's original taxonomy model was revised in order to address certain perceived weaknesses associated with the original model, most notably that of the assumption that the cognitive path was stated as being 'one-dimensional' in order of its complexity (Amer, 2006). It was found that when the original taxonomy was used, frequent contradictions arose due to the inversion of certain tasks within the structure, with certain knowledge demands being more complex than those demands placed on evaluation or analysis (Ormell, 1974). A further reason for the need to revise the original taxonomy model stemmed from the fact that since the original publication, modern learning practices have made students more responsible for the learning, thought and understanding that the subject material requires. The revised taxonomy was designed to incorporate the paradigms associated with this learner-centered approach.

Level 1:	Remember
	(1.1) Recognition (1.2) Recalling
Level 2:	Understand
	(2.1) Interpreting (2.2) Exemplifying (2.3) Classifying (2.4) Summarising (2.5) Inferring (2.6) Comparing (2.7) Explaining
Level 3:	Apply
	(3.1) Executing (3.2) Implementing
Level 4:	Analyse
	(4.1) Differentiating (4.2) Organising (4.3) Attributing
Level 5:	Evaluate
	(5.1) Checking (5.2) Critiquing
Level 6:	*Create*
	(6.1) Generating (6.2) Planning (6.3) Producing

Figure 5: Bloom's Revised Taxonomy Model (Amer, 2006)

The rationale behind the revised taxonomy model originated from the recognition that the original model did not address the multi-dimensional aspect that the learning outcomes usually contain, both in (a) subject matter content and (b) what is required to be done with that content. As such, the table was configured to contain both (a) the noun phrase and (b) the verb phase, which represents the cognitive processes involved with each stage of the model (Krathwohl, 2002), and separates the noun and verb aspects into different dimensions (which was not the case with the original model). With the original model, the six major categories were given greater prominence in relation to the sub-categories. The revised model addresses this by placing greater importance on the nineteen cognitive processes within the six categories, as listed in Figure 5.

In order to effectively solve problems at the higher end of the revised taxonomy scale, it is a necessity that the knowledge learned becomes an integral part of a student's long-term memory. Once meaningful understanding of a topic is achieved, it is possible to perform higher levels skills such as the analysing of knowledge, the evaluating of knowledge and the creation of knowledge. Memory systems are generally classified into long-term[25] and short-term or 'working-memory'[26] systems, with the two being completely independent of each other. Incoming information is handled initially by the working-memory (which is limited in processing capacity) through interaction with knowledge stored within the long-term memory (Novak & Cañas, 2006). In order for large amounts of knowledge to be processed in this manner, an orderly structure is required to assist with the categorisation of the knowledge, thereby becoming meaningful to the student.

The role of prior knowledge

For learning to be regarded as a change process, and in order for this change to be measureable, it becomes a requirement to measure prior knowledge in order to form a baseline for its development. Hay, Kinchin & Lygo-Baker (2008) believe that students with a better understanding from prior knowledge that has been learned can more easily make sense of what is being taught. In this context, the authors believe there to be three elements to prior knowledge that can affect a student's ability to retain information. These can be listed as (a) an overlap between prior knowledge and what

[25] A system for permanently storing, managing, and retrieving information for later use. Items of information stored as long-term memory may be available for a lifetime (Bailey, Bartsch & Kandel, 1996).
[26] Working-memory is a system for temporarily storing and managing the information required to carry out complex cognitive tasks such as learning, reasoning, and comprehension (Bailey, Bartsch & Kandel, 1996).

is being taught, (b) how prior knowledge has been structured, and how open this structure is to change, and (c) misconceptions within the prior knowledge structure that can hinder the processing of new knowledge.

The Bloom's revised taxonomy model has been used to set certain key assessments during the course of this study, with the aim of analysing the student results from these assessments to ascertain where on the taxonomy scale the primary strengths and weaknesses lie on the part of the students. During the third phase of this study, the successive group results are to be compared in an attempt to see whether or not the learning methods that were introduced (group-based learning and case-based learning) have had any impact in terms of the levels of comprehension as categorised through using the revised taxonomy model.

In order to enhance the quality of the teaching and learning process, as well as to aid the thinking process on the part of the student, it is important to formulate the material in a manner that can appeal to the individual's preferred styles where possible. One way to accomplish this is through making more use of the senses available to the students. The use of various sources of multimedia has the ability to appeal to many of the different preferred styles, through appealing to these different senses (i.e. sight, audio, visual).

2.5 Multimedia use and its effect on the learning process

In education today, the use of multimedia in classrooms has become commonplace as (a) lecturers attempt to make the learning process more meaningful, and (b) in order to appeal to the different learning styles of the students. The behaviourist[27] way of thinking was ever present in earlier forms of educational software, which were designed primarily to reinforce concepts. The more modern approach is to develop 'constructionist' software models that are able to engage the students, and allow for more open-ended exploration (Kearney & Treagust, 2001). Research has shown that a complementary relationship to exist between constructivism and technology, whereby each one is of benefit to the other, with success being reported through the use of constructivist course modules (Nanjappa & Grant, 2003). Rakes et al. (1999) agree

[27] In the Behaviorism approach, a change of behavior is required in order to demonstrate learning. In this regard, the learner must respond to the environment, stimuli, and reinforcements in order for the Behaviorist to claim that learning has occurred (Fields, 2011).

with this view, believing that 'technology can provide the vehicle for accomplishing constructivist teaching practices'.

According to Squires & Preece (1999), constructionist software models should allow for 'cognitive authenticity'[28] through the promotion of allowing learners to engage with the tasks, to articulate ideas and to express opinions. At the same time, constructionist software should also allow for 'contextual authenticity' through relating the tasks being done to the real world, and through the promotion of collaborative learning methods.

Through multimedia use, and the linking of images or system animations to text, a deeper understanding of the subject matter can be possible (Mayer & Moreno, 2002). This process is a direct result of the association that is formed through the linkages within the material, as opposed to the requirement of mentally forming the connections oneself. In this way, an environment is created in which more than one of the senses are involved in the processing of the received information, thereby reducing the working-memory load of the student through the more efficient utilisation of their long-term memory.

Research has shown that computer animations have the ability to aid content understanding on the part of the students. This is especially true in the case in engineering education, where it is easily possible to illustrate various engineering concepts such as how a certain type of pump works, or how hydraulic systems operate. Mayer and Moreno (2002) believe that the animations should exclude sounds, narrative or music where possible in order to have the best possible effect. This is primarily due to the student having more cognitive resources at their disposal to mentally build linkages within the material. Through a combined method of audio and visual media delivery, as opposed to receiving separate forms of stimulus (that is commonly used), the students are better able to utilise their working-memory. This positively influences the student's ability to recall the subject matter at a later stage (Kalyuga, Chandler & Sweller, 2000).

Caution is however advised when it comes to the presentation of information in this manner, so as to avoid information redundancy, whereby similar threads of information are fed to the student through different sources. This practice increases the cognitive

[28] Authenticity (philosophy): a particular way of dealing with the external world, being faithful to internal rather than external ideas.

load through the need to process certain pieces of unnecessary information. It is here that one needs to distinguish between whether the information provided is redundant, or merely a revision of prior knowledge, as in the latter case, revision does not place an additional load on one's working-memory. Kalyuga, Chandler & Sweller (2000) found a correlation to exist between one's level of experience, and the emphasis placed on certain components within a combined tuition format. As experience is gained, a greater reliance is placed by the student upon diagrams as opposed to any accompanying text, with the text then moving towards becoming redundant information.

The format of the various multimedia design elements needs consideration in order to avoid the possibility of placing unnecessary cognitive load through the organisation and design of the subject matter (Sweller & Chandler, 1994). For the multimedia design elements to have the most impact, the layout and method of placement need be as simple as possible, thus ensuring that the cognitive load is primarily as a result of the task at hand, and remains focused on that particular task.

If one views the merits of animation from the perspective of a reduction in cognitive load, there are two primary functions of the animation that require consideration. The first of these is the animations' enabling function, whereby the animation promotes a deeper form of subject understanding which would not necessarily be the case otherwise, and the second being a facilitating function, which is a reduction of the mental effort required on behalf of the student. In terms of those students with lesser ability and experience, the displaying of dynamic system processes through the use of animation is especially beneficial (Sweller & Chandler, 1994). With this in mind, it is important that the use of multimedia should not be overdone, and that sufficient time be allocated for 'quiet contemplation and purely mental consideration', especially for tasks that require a higher level of intellect.

With the multimedia components being suitably configured, greater emphasis can be placed on the use of the various learning methods in order to make the learning tasks as meaningful as possible, and to reduce any mismatches that exist between the teaching and learning styles.

Through the integration of technology and constructivist methods like project based learning[29], learners become more involved in the process of learning (Grant, 2002). In the section that follows, different learning methods will be reviewed, with those deemed to be the best suited towards meeting the ideals of Novak, Vygotsky, Papert, Bandura, Kolb and Sternberg accepted for use in this study.

2.6 Inquiry based learning methods

Inquiry based learning (IBL)[30] is an inductive[31] learner-centered process that aids cognitive development through taking knowledge learned from one source and transferring that knowledge to a new application or scenario (Prince & Felder, 2006). According to Albanese (2000) people are the most motivated in terms of learning new facts, when they clearly perceive the items to be learned are worth knowing. With inquiry based learning methods, students are required to analyse data or scenarios in order to solve problems, and in the process, they generate the need for factual understanding of the topic and the underlying principles (Prince & Felder, 2006).

The effectiveness of inquiry based learning methods has been the subject of conflicting viewpoints within academic literature (Prince & Felder, 2006; Kirschner, Sweller & Clark, 2006; Hmelo-Silver, Duncan & Chinn, 2007), largely as a result of the freedom that is associated with inquiry based learning methods. Kirschner, Sweller and Clark (2006) believe that the root of the problem associated with IBL lies with the fact that the freedom of exploration that IBL allows for within a complex environment, can divert the student away from the actual learning process. Despite agreeing in principle, Hmelo-Silver, Duncan & Chinn (2007) believe that the research conducted by Kirschner, Sweller and Clark (2006) combined numerous pedagogical approaches indiscriminately, under the guise of 'minimally guided' instruction processes, and that IBL is not an unguided process. The scaffolding methods that are used within IBL methods are able to facilitate a better student-learning environment, without actually detracting from the learning process (Hmelo-Silver, Duncan & Chinn, 2007).

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[29] Project-based learning blends traditional subject-matter goals and objectives with authentic learning environments. The primary rationale for using authentic activity forms is the enhanced understanding that develops through application and manipulation of knowledge within context (Eskrootchi & Oskrochi, 2010).

[30] Sometimes referred to as enquiry based learning (EBL), especially within British literature.

[31] Characterised as constructivist methods, on the principle that students construct their version of reality as opposed to adopting the versions presented by their teacher (Prince & Felder, 2006).

Methods that can be adopted to provide a more guided approach to the instruction include the formulation and adaptation of process worksheets as a form of scaffolding (Van Merriënboer, 1997). Such process worksheets are able to provide a guideline of the path that should be followed for the process of the solving of problems, as well as to indicate direction with the learning process (Kirschner, Sweller & Clark, 2006).

Staver & Bay (1987) place the inquiry process into three distinct categories:

(1) The first category describes a process of structured enquiry, whereby the students are presented with a particular problem and are given a guideline as to how to solve the problem.

(2) The second category describes a process of guided enquiry, whereby the students are additionally required to figure out the method for the solution to the problem that is presented.

(3) The third category describes a process of open enquiry, which requires the students to formulate the problem for themselves.

For the purpose of this study, IBL as a learning method (integrated within the designed CBT model) is to be regarded as being a structured inquiry process (Staver & Bay, 1987) that utilises extensive scaffolding (Hmelo-Silver, Duncan & Chinn, 2007) in order to provide direction for the students, thereby adopting the view of IBL held by Hmelo-Silver, Duncan and Chinn, over that of Kirschner, Sweller and Clark.

2.6.1 Scaffold learning methods

Within the field of Educational Psychology, scaffold learning is a term that refers to the devices and support mechanisms that are able to support the learning ability of the students (Rosenshine & Meister, 1992). The scaffolding process refers to a method of ‘performance support and fading’; with support being offered when it is required by the students, and withdrawn as the students achieve the desired goals (Van Merriënboer, Kirschner & Kester, 2003). With regard to novice learners, Van Merriënboer, Kirschner and Kester (2003) advocate full support in order to reduce the extraneous effects on the cognitive loading.

With regards to hypermedia environments[32], the use of different forms of media requires a greater degree of learning regulation on the part of the learner. This is because that within hypermedia environments, a fixed scaffolding formation has been shown to be less effective as a support mechanism than an adaptive form of scaffolding (Azevedo & Cromley, 2004). The benefits derived from an adaptive environment are largely due to the process of the facilitator continually monitoring the progress of the students, and offering timely support as and when it is required. This adaptive support is required to be implemented cautiously, so that the support offered in no way impacts the self-regulatory behavior on the part of the students (Azevedo & Cromley, 2004).

Scaffolding activities within a CBT environment can adopt various forms, each with a slightly different objective but common goal of providing a mechanism for support and fading. The most prominent of these formations can be described as follows:

(1) One method is to utilise completion task activities. This form of scaffolding combines the strong points of worked-out examples and conventional learning tasks. Like conventional learning tasks, completion tasks directly encourage learners to be active participants as they are required to complete the solution to the particular problem, which is only possible by carefully studying the partial example provided by the lecturer in the completion task. Completion tasks have been shown to have the same affect with decreasing extraneous cognitive load, in a similar manner that worked-out examples are able to (Van Merriënboer, Kirschner & Kester, 2003).

(2) A second form of scaffolding activity can include the formulation and use of goal-free tasks. Goal-free tasks present the learner with a highly aspecific goal, which has the outcome of eliminating the need for searching for a means to an end. This process results in a subsequent reduction in extraneous cognitive loading means–ends searching, and as a result, decreases the extraneous cognitive loading on the part of the student.

[32] Hypermedia is an extension of the term hypertext which refers to a non-linear medium of information that includes graphics, audio, video, plain text and hyperlinks. This contrasts with the broader term multimedia, that may include non-interactive liner presentations as well as hypermedia.

(3) A third form of scaffolding activity can include the use of tasks termed 'reverse tasks'. These scaffold activities present the learner with both a goal and a solution, and the student is required to determine for which given situations the solution may be helpful in reaching the intended goal.

The scaffold learning process that has been used during this study incorporates different scaffolding formations, each with the aim of engaging the student and attempting to place the material learning process at the forefront, while simultaneously reducing the cognitive loading process as much as possible.

Scaffolding in the context of this study adopts the principles of skeletal mapping structured assignments (Chatterjea & Nakazawa, 2008) to fulfill the support mechanisms as detailed by Rosenshine and Meister, (1992). The support offered in terms of a structured framework that the students' are required to work within, will be faded out as the student progresses (Van Merriënboer, Kirschner & Kester, 2003), thereby adopting an adaptive method of support (Azevedo & Cromley, 2004).

2.6.2 Problem-based learning methods

Problem-based learning (PBL) is a further discipline of the inquiry-based learning approach to education, having its roots embedded in medical education. The underlying framework of PBL is that new information and challenges are dealt with through the activation and manipulation of prior learned knowledge. The learning process occurs mainly through the identification of how that which has been learned can be applied to real life scenarios. Following on from this step, a process of reflection, discussion and questioning of the associated outcomes allows for the learners to develop a greater understanding of the subject matter, and an understanding of how it can be manipulated in order to solve various problems. It has been found that conceptual change is enhanced through the challenging of one's existing knowledge, where the existing knowledge structures are found to be lacking. Once the required knowledge to solve a problem has been restructured, a deeper understanding of the subject matter results (De Grave, Boshuizen & Schmidt, 1996).

It is understood that change is also stimulated through the need to explain one's findings, and to defend one's understanding in order to build on the existing knowledge framework. In certain instances, PBL can induce a healthy cognitive conflict among collaborative groups, thereby accelerating a change in individual conceptual understanding. When students are being afforded more freedom of thought than traditional learning styles, the role of the educator needs to take on that of a facilitator of the process. The primary aim of the facilitator is to construct a framework to work within, which the students are able to utilise in order to construct their own knowledge structures (De Grave, Dolmans & van der Vleuten, 1999). A perceived negative aspect of PBL is that the learning method affords the students more freedom for discovery, which can often result in the learning process branching off into tangents, and away from the desired focal point. In this regard, critics of the PBL model believe that without a guided enquiry process, conclusions can be derived at that are somewhat incorrect (Srinivasen et al., 2007).

Hmelo-Silver (2004) describes PBL as a process whereby students are required to reflect upon their experiences on the path towards the solving of ‘ill-structured’ problems. This point has to be raised as a concern in the South African Marine Engineering student context (with students at the operations level of Officer of the Watch), due to the fact that the students have very little (if any) prior experience to draw upon. A further consideration towards PBL as a theoretical tuition model comes from a study conducted by Dochy et al. (2003) that found PBL to have had no effect on measure of factual knowledge during the duration of the study that was conducted. On the question of intrinsic motivation, Hmelo-Silver (2004) states that the limited research that has been conducted to date on this topic has been unable to prove this point with any certainty. From a study conducted by Derry et al. (2000), it was found that while many students reportedly enjoyed the lessons, others were resistant towards changing their learning methods, or were opposed to collaborative tuition methods.

A further study conducted by Mills and Treagust (2003) was configured to look at the effectiveness of PBL within engineering education, in which the authors stated that there appeared to be obstacles with regards to the implementation of PBL learning practices across the engineering program that was under review. The authors further believed that PBL may in fact have resulted in a ‘less rigorous’ understanding of engineering principles being achieved. Perrenet, Bouhuijs and Smits (2000) believe some of these obstacles stem from the fact that a large portion of engineering education is hierarchical in nature, meaning that if certain sections are omitted, challenges will be experienced with the learning of concepts later on. This is in contrast to the medical field that deals with knowledge that is more encyclopedic in nature, resulting in missed knowledge pieces having lesser impact on the learning of concepts.

In terms of MET, PBL has been adopted as a method of tuition at Dokuz Eylul University School of Maritime Business and Management (SMBM), for the Deck Department. In this setting, the students have found the PBL environment to be relevant, challenging and enjoyable as a learning method (Tuna et al., 2002). It is felt by SMBM that PBL contributes towards a quality education system for MET use, stating simulation as one of the positive outcomes. Within this environment, no mention is made of PBL as a learning method for the Marine Engineering programme.

Within the context of this study, PBL was adopted as a learning method as part of the structured scaffolding of the assignments only, and not as a key learning method trialed over the data collection phase. The target group during this phase of the study comprised students at the most senior level, which discounts the lack of experience encountered at the lower levels. It was intended that this PBL study test the effectiveness of the students reflecting on prior experience in a less structured manner (Hmelo-Silver, 2004), and to determine if PBL in a maritime context agrees with the hypothesis of Mills and Treagust (2003), namely that effectiveness of PBL tuition in an engineering context has been found to be largely inconclusive.

2.6.3 Case-based learning methods

Case-based Learning (CBL)[33] is a learning method that uses the process of referring to previous similar situations (cases) and transferring any relevant knowledge to the particular situation that is being studied. The learning process comes about as a by-product of the problem solving process, with the information being retained for the solving of future problems that are similar in nature (Aamodt & Plaza, 1994).

CBL is an approach to education that also concentrates on stimulating a creative problem solving approach after the students have prepared in advance for the days learning, through the prior revision of the core subject matter. With regards to Marine

[33] Sometimes referred to as case-based reasoning (CBR).

Engineering education, this form of tuition is well adept to the learning of maintenance procedures and for understanding what actions should be taken under certain operational circumstances, as opposed to the key objective associated with purely solving a particular problem.

The underlying concept of CBL involves the organization, retrieval, utilisation and indexing of knowledge in the process of solving a problem. CBL can take on different forms, and according to Aamodt and Plaza (1994), CBL can be broadly classified as follows:

(1) Exemplar-based case studies: The solving of exemplar-based case assignments is one that is reliant on the solving of problems becoming a process of classification of the particular task (i.e. finding the correct category).

(2) Instance-based case studies: This form of CBL model is designed to compensate for a general lack of guidance in terms of a student not having sufficient background knowledge of the topic. Instance-based cases rely on the provision of many instances of a possible solution for a student to utilise, in the process of solving a particular task.

(3) Memory-based case studies: This CBL case type includes the use of a large memory (index) of cases that have been built up, with the students addressing tasks by searching through this memory bank (library) to retrieve the relevant information required to solve the case.

(4) Case-based[34] case studies: This type of case study refers to the typical cases that can be a source of information that is rich in content. This content is available for retrieval and adaptation for use with alternative scenarios as the need arises.

(5) Analogy-based case studies: This process refers to the use of information that can be retrieved from a different domain, and used in the context of the particular case being addressed.

[34] Although case-based reasoning is used throughout this paper as a generic term, in this context it is used in the purest form.

CBL has been influential as a learning tool through its use of extensive case libraries, allowing for students to learn from the experiences of others. In terms of the lesser-experienced students, certain strategies can be adopted, and procedures and task beginning points can be derived at from these libraries (Kolodner & Guzdial, 2000).

The CBL cycle of information management is described by Aamodt and Plaza (1994) as a closed loop process that includes the information retrieval from similar cases, the reuse of that information within the context of the case at hand, a revision of the case solution and finally a retention of the knowledge derived at for future use.

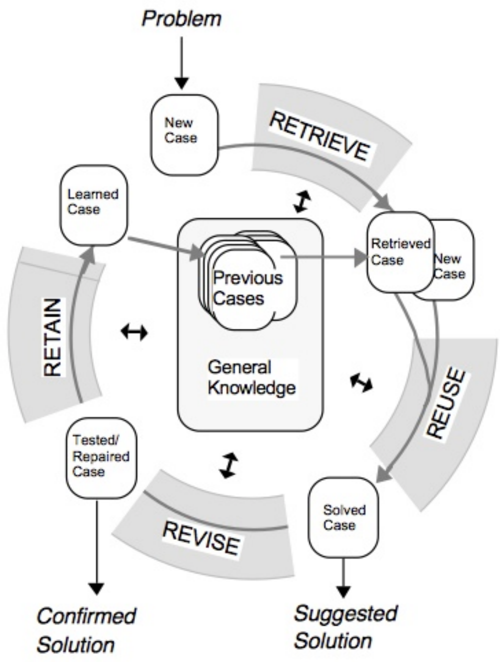

Figure 6: Aamodt & Plaza's (1994) CBL information management diagram

Critics of CBL point to the notion that the model stifles one's inherent curiosity, which ultimately tracks the learning experience away from that of facilitation towards the more traditional lecture-based approach. However, there are many findings with regards to both the short-term knowledge acquisition and the long-term information retention improvements (Cliff & Wright, 1996) that can be obtained from the learning method. Flynn and Klein (2001) state that the use of discussion groups is common within a CBL environment, with the authors believing that discussion is a key component of the case-solving process. Droge and Spreng (1996) agree with this view, believing that student-led CBL classes have been found to deliver more favourable outcomes in comparison to purely instructor led forms of CBL.

Case based learning as used within this study

For the purpose of this particular part of the study, it is seen as being prudent to address the lesser levels of experience among the student groups as a primary purpose of introducing CBL methods into the study. In this regard, the definitive use of CBL in this context is to follow the memory-based approach detailed by Aamodt and Plaza (1994), using the retrieval, reuse, revision and retention of library information as a knowledge source. The case-solving process is to follow a student-led approach (Droge & Spreng, 1996) within the environment of small focus groups (Flynn & Klein, 2001).

2.6.4 Group-based learning methods

One of the bigger challenges facing a student who has limited seagoing experience, is that they are often unable to form the required cognitive connections within the material as presented in class, to the respective equipment that can be found onboard a ship. This discourse is worsened by the pace and complexity of the study programme, or if there are external environmental factors that need to be taken into account (Prasad, Baldauf & Nakazawa, 2011). When these factors are present, the learners tend to become mentally disassociated from the class. To counter this phenomenon, curricula that incorporate self-reading practices, peer assistance and tutorials have risen in prominence, with the primary objective being the maintenance of active cognitive involvement on behalf of the learner. It is here that group-based learning approaches have particular merit, in that prior knowledge gained through individual experience can be pooled, and passed on within a peer-to-peer learning environment.

GBL involves the restructuring of the classroom environment, away from a lecture-centered approach towards embracing and incorporating this peer-to-peer learning element. GBL has gained popularity in recent times due to its ability to enhance the classroom experience for the learner. The learning outcomes of academic and cognitive development, educational goal clarity and class involvement, have all been found to be positively influenced through this learner-centered process (Cabrera et al., 2002). Dym et al. (2005) believe that there is enough evidence to support the theory that IBL also has the ability to encourage GBL, whilst enhancing critical thinking skills.

GBL allows for the learners within the group to form constructs within the material in a meaningful manner in order to derive solutions to challenges, as well as to transfer the knowledge[35] related to the task at hand amongst the group participants. As is the case with other prominent learning methods, the various terms within the GBL approach can be somewhat confusing. For clarity, Smith et al. (2005) make the distinction whereby they classify co-operative learning as a learning method that is carefully constructed so as to ensure individual accountability (as was used in the model by Chatterjea and Nakazawa at the SMA), whilst collaborative learning is not structured with the aim of ensuring individual accountability. Co-operative learning is a collaborative learning approach that adopts a more structured stance towards the process of IBL. In addition, the role of the facilitator requires that a greater degree of control be exercised in order to maintain the focus of the groups (Prasad, Baldauf & Nakazawa, 2011). This approach is beneficial when a degree of time management is required, as well as to ensure that the individual groups do not deviate away from the activity's core focus to any great degree. Greater facilitator involvement will also ensure that all individuals within the groups contribute meaningfully to the outcomes of the task, thus reducing the possibility of those fringe learners being left out of the process (Prasad, Baldauf & Nakazawa, 2011).

A key component of a successful co-operative learning environment is that of positive interdependence within the individual groups, where the students feel they cannot succeed unless the rest of the group succeeds as a collective. Interdependence theory states that mutual efforts created through the establishment of common goals, has the outcomes of producing a 'dynamic whole', whereby the change in one member within the group positively changes the state of the other group members. This positive group interdependence results in the individuals cooperatively working together to aid others in the group in the learning process. In contrast, negative interdependence (that arises through a competitive element within the task solving process) can have outcomes

[35] The transfer of knowledge referred to alludes to how knowledge acquired on one situation applies (or fails to apply) to another (Argote & Ingram, 2000).

whereby members actually hamper the efforts of others within the group (Smith et al., 2005). Positive interdependence is able to promote a scenario of promotive interaction, which is a term used to describe group members actively encouraging the other group members towards the achievement of the group's objectives. As each group member gets tasked with making a unique contribution, they begin to accept a responsibility towards making the joint group effort beneficial. The last essential component of successful co-operation (with regards to learning) is that of individual accountability, as responsibility forces are increased when there is both group and individual accountability (Johnson & Johnson, 2009).

There are various methods aimed at ensuring positive interdependence within the co-operative groups, which can be described as follows:

(1) The first method described is that of goal orientation, whereby the common goal is the key element that binds the group. It is then the requirement that the collective group fares upon the outcomes of those assigned goals.

(2) A second method of ensuring positive interdependence revolves around the reward process, where each member of the group receives the same reward, if the assigned outcomes of the tasks are achieved.

(3) Resource interdependence is the third approach, one that gives each team member a portion of the materials or tasks required in the solving of the particular task, and the collective effort is what constitutes the outcomes.

(4) The final method of ensuring positive interdependence is that of role interdependence, which describes a system whereby inter-connected responsibilities are required to be pooled in order to attain the objectives of the group.

Successful positive interdependence achieves promotive interaction (Johnson, Johnson & Smith, 2007). This promotive interaction facilitates a peer encouragement action and the transfer of knowledge among the group participants. Further benefits of this promotive interaction include the provision of a peer feedback mechanism, and a platform that allows the individual group members to positively challenge existing thoughts with the aim of intellectually advancing the learning process.

Individual accountability remains the cornerstone of a successful co-operative learning system. After the process, the primary aim has to be that of equipping the student with the ability to tackle similar tasks by themselves. In order to establish a system whereby individual accountability comes about, it is a requirement that the groups be kept fairly small, that the tests are done individually and that the students are randomly quizzed about aspects of the groups work. In this way, where students ‘learn together but perform alone‘, the phenomenon of group ‘hangers-on’ are eradicated.

Students are interested in the ideas of others, especially those of their peers, as different ideas and thought processes cause them to review different alternatives. Co-operation, compared with individualism and competition, tends to result in higher achievement and better long-term retention of what has been learned (Gokhale, 1995; Johnson, Johnson & Smith, 2007; Smith et al., 2005).

The structure of the co-operative learning groups can take either a formal or an informal form. The informal guise is a more ad-hoc arrangement, with collaboration being from a few minutes stretching to the entire period, depending upon the circumstances involved. Informal co-operation has the primary aim of ensuring that when a student is uncertain about a section of the work, this void is quickly identified and corrected in a personalised manner. Whilst this at times may be seen to reduce the time that is available for the lectures, the practice has been seen to re-invigorate the students (Smith et al., 2005). Additionally, the break allows for the lecturer to re-evaluate, walk around and engage with the students so as to better the understanding of the level of student comprehension of the topic. Formal co-operative groups are more structured by nature, where certain responsibilities can be assigned to the individuals so that each member is able to positively participate with the assignments as given to them.

Individual accountability can be enhanced through limiting the size of the groups, via group observations, through task and role assignment, and through individual testing procedures. Similarly, if students periodically assume the role of explaining what they have learned to other members within the group, they can positively question whether or not their own understanding of the subject matter is indeed correct, within a positive interactive learning environment. Additionally, as the lecturer observes these unstructured explanations, they are better able to grasp the level of understanding among the groups, and provide guidance as required to the student.

Creating inductive tuition systems can however contrast with the deductive preferences of many of the learners, whose primary aim is the acquisition of knowledge solely to pass the next test, and nothing more. A lack of cognitive involvement can result in a return to rote learning, and the aim then becoming to obtain an examination pass (Prasad, Baldauf & Nakazawa, 2011). This process ultimately ends up failing the industry, as little is achieved in terms of fostering a deeper understanding of the subject knowledge (something that is required onboard ships). In order to be effective, and to be able to cater for both intuitive and sensory learners, the material delivered needs to contain both concrete facts, and abstract principles, whilst actively engaging the learner.

With regards to an engineering course, it is a requirement of the engineering lecturer to not only look at how the course theory is compiled, but also how to deliver the content in a manner that is able to engage the student. With co-operative learning, the objectives for the groups have to be specified, the methods of doing the tasks have to be suitably devised, the tasks are required to be clearly explained, and finally the outcomes need to be monitored and properly evaluated. Engineering education models have been revised to a certain extent through an industry need that realises that engineers need to become experts, who develop an internal desire for lifelong learning practices. In addition, new models of engineering education that are able to utilise a GBL approach, have positive outcomes in terms of producing engineering graduates that are well adept to teamwork (Dym et al., 2005).

Group-based learning as used within this study

For the purpose of this study, the GBL approach is to embrace a co-operative learning method of instruction, adopting the definition of Prasad, Baldauf and Nakazawa (2011). in being a collaborative learning approach that retains a more structured approach towards the process of IBL. The method of co-operative learning is to follow an informal process (Smith et al., 2005), with the intention being to assist in better integrating the cultural and language differences that exists among the students, within the class activities.

2.6.5 Inquiry based learning summary

For the purposes of this study, it is prudent that the choice of learning methods adopted be clarified. The learning methods that have been chosen all fall under the umbrella of IBL, being an inductive aid to cognitive development through taking knowledge learned from one source and transferring that knowledge to a new application or scenario. The method by which this is done is within a constructivist scaffold-learning environment, where the support structures are withdrawn as subject competency is demonstrated.

GBL for the purposes of this study refers to the peer-learning process that is promoted through the collaborative design element that the courses adopt in the third phase of the study. Within this collaborative learning environment, falls the chosen learning method of CBL. CBL describes a learning method that makes use of referral to previous similar situations that have occurred (cases) and transfers any of that relevant knowledge to the particular situation that is being studied.

While PBL has been mentioned in this study (and would also fit alongside CBL to be used in a group environment), PBL as a learning theory has not been adopted for trial within this study.

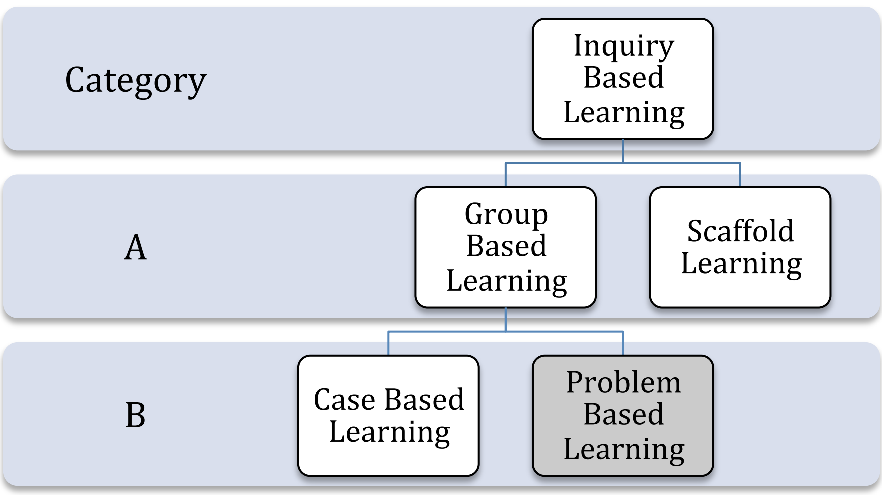

Figure 7: Learning methods clarification flowchart

2.7 English language ability and its effect on maritime education

Given the many languages that are spoken within South Africa, and the stated fact that CPUT enrolls students from the entire Southern African region, it is required to investigate what degree of correlation exists (if any) between a student's English speaking ability and their written performance within the subject area. Research conducted by Cardeño (2004) shows a positive correlation factor to exist between someone's higher oral ability and their written performance. This finding reflects upon the belief that the way we learn about written language is similar to the way we learn to talk.

While very few students attending CPUT have English as their home language, the level of understanding in English is perceived to be relatively high in comparison to other parts of the world. Whilst a certain level of English language proficiency is a requirement in order to comprehend the study material as presented to them, those students who are less proficient in the English language can often aid each other in terms of comprehension. This practice is easily facilitated through the collaborative process that arises as a result of a GBL method of tuition. Consideration was initially given to incorporating a 'language assistance' function with regards to the CBT design process, however with the vast number of African languages among both the local and foreign students, coupled with little translation media being published for certain of these languages, this was deemed to fall beyond the scope of the CBT design parameters of this study. For this reason, preference was given towards the adoption of the respective learning methods that are aimed at clarifying any language ambiguities as much as possible, through a peer learning process.

From past experience gained with foreign students at CPUT, language is often presented as a reason for a lack of assessment and examination question understanding on the part of the student. Caution needs be exercised in this regard however (at examination time) to ensure that the assistance given to the students with regards to language ambiguities is in fact language related, and that language is not used as an excuse in an attempt at gaining an unfair advantage from a content perspective (i.e. gaining hints on how to answer the question).

It is therefore important to collect data in this regard to be used for the compilation of the CBT syllabi, and in order to ensure that the choice of learning methods introduced are the correct ones for the application. Certain maritime and engineering words and phrases are unclear even to the English-speaking students, especially those students that are lacking any form of prior industry experience, as much of the shipping terminology in use is often passed down from previous generations. For this reason, the stimulation of discussion within a group perspective is intended to aid in clearing up as much of this ambiguity at the lesson phase, well before any assessments or examinations are required to be done by the respective students.

Summary

Taking into account the need to embrace the selected learning methods into what is taught within a classroom environment, and to assist those students who are not fully proficient in the English language, the choice of software model used, and the development thereof became important. The chapter that follows outlines each of the more prominent learning management systems and computer based training programs in turn, so that the reason for the choice of model adopted can be clarified.

CHAPTER 3

COMPUTER-BASED EDUCATION MODELS

Introduction

The CBT model that is required to be used as the vehicle to incorporate the chosen scaffold design elements and learning methods chosen, had to fulfill the requirements of the institution (from a cost and management perspective), as well as that of the students (from an end-user perspective). To ensure that the system selected was the best choice to work within the environment as found at the CPUT DMS, it became necessary to conduct a review of the prominent learning management systems (LMS) and CBT models available today.

This chapter also looks at concept mapping when used as a teaching and learning tool, and how effective this has been through looking at previous studies conducted using Novakian concept maps. The requirements of the institution and that of the student are also explained in detail, to assess the workability of the developed CBT model. Before looking at these items however, it is prudent to review the challenges identified through similar case studies that have been conducted in other developing countries (that have introduced CBT models of education), as well as looking at what has been found previously within South Africa.

For the purposes of clarity when comparing this particular study to studies of a similar nature done elsewhere, this study is referred to as the CPUT DMS study. Within this study, reference is made to another study that was previously conducted that included CPUT as an institution; this study has been referred to as the CPUT/UCT/WITS study.

3.1 Introducing computer based education models

This CPUT DMS study aims to develop, introduce and test a CBT model for maritime use that will be of assistance to the type of student that pursues as maritime career in a developing country that is not able to offer the same resources that are enjoyed by the more developed maritime nations. The younger generation of students who start to study at maritime institutions, do so in an academic environment that has evolved in line with the costing model of higher education in South Africa. As a result of payment being forthcoming from government depending upon institutional throughput, the institutions prioritise throughput (i.e. academic studies first before any practical component is undertaken). This poses challenges in an engineering discipline, where a practical understanding aids the students at the time when the academic studies are done.

It is for this reason that this study has been motivated. It is important that in order to develop and test a suitable CBT model for this type of environment, the challenges faced within similar environments be noted.

3.1.1 Challenges faced by developing countries introducing a CBT model of education

Two of the following studies share a similar environment to that found at the CPUT DMS, and therefore may add value in terms of identifying the challenges that will likely be faced in a study of this nature. The third study is one that has been previously done in South Africa, looking at the impact that ICT has on students and academics at universities in the respective regions. These studies are introduced in this section, along with the concerns noted from each region, and will be reviewed in the discussion and recommendation chapter along with the findings from this particular study done at the CPUT DMS.

The first of the comparative studies to be reviewed was a case study conducted by Anderson in 2008 at the University of Colombo School of Computing (UCSC)[36] in Sri Lanka. The UCSC study looked at the challenges that were faced when distance-learning computer-based courses were introduced. To gather their data, the researchers developed and used 37 enablers or disablers, in order to ascertain the most prominent stumbling blocks that were experienced by the students. A total of 1887 samples were attained between 2004 and 2007. The major challenges identified from these 37 factors, included student support, flexibility, teaching and learning processes, computer access, student academic confidence, localisation of content and

[36] Hereafter referred to as the UCSC study.

the attitude towards computer based learning. This study was chosen for comparison due to certain of the abovementioned factors being a possibility within the CPUT DMS environment.

The second study that shares similarities with the CPUT DMS study was a case conducted by Asunka in 2008, that took place at the Regent University College of Science and Technology in Ghana. The RUCST [37] study involved a group of undergraduate students that were enrolled in an online course between 2006 and 2007 in Ghana. The system that was introduced allowed for the students to collaborate using various technological initiatives that had been devised, in order to derive solutions to problems that were posed to them. The study was small in nature, with 26 samples providing initial qualitative feedback indicating that they believed that no advantages could be gained by computer-based learning over traditional classroom tuition methods. For this reason, this study was chosen for comparison in order to review the CPUT DMS findings (in terms of noted advantages and disadvantages) with that of those noted at the RUCST.

A third study that has been used for comparative purposes, a case study done by Addo and Railton in 2008 in South Africa, involved 307 students and 15 academics to assess the impact of ICT at three institutions, namely: The Cape Peninsula University of Technology (CPUT), the University of Cape Town (UCT) and the University of the Witwatersrand (WITS) in South Africa[38]. In this study, the researcher developed and used a qualitative survey to retrieve information from those participating as to their preferences regarding different forms of technology that could be used for educational purposes. The Addo and Railton case study was selected in order to review the findings with regards to the impact that certain technologies had (CPUT/UCT/WITS study) with what was noted in this study (CPUT DMS study).

Further comparisons with regards to the findings of the CPUT DMS study to these studies mentioned above will be discussed in greater depth in the discussion section that follows.

[37] Hereafter referred to as the RUCST study.
[38] Hereafter referred to as the CPUT/UCT/WITS study.

3.1.2 Computer based education models for maritime use

Recently in South Africa, emphasis has been placed on making affordable tablet computers available to the students at both secondary and tertiary education institutions. This has been done in limited quantities in an attempt to modernise the country's educational practices, and to develop computer-aided education programmes. This process also has an effect of attempting to reduce the amount of paper consumed in the process of content delivery. There has also been extensive dialogue as to the best methods to relate to today's generation of student, to ensure that the learning process and teaching methods are not out of date with South Africa's youth.

It has been found that rapidly changing technologies have created a mismatch between the static model of competence standards that are set by MET institutions, and the dynamic competencies that are demanded by these changing technologies (Prasad, Baldauf, & Nakazawa, 2011). It is also believed that incorporating updated technologies into the curricula in the maritime domain can be difficult, owing to the fact that the content used is based on published literature, which is often somewhat 'out-of-phase' with modern shipboard practice.

A similar challenge exists in South Africa with regards to the formulation of curricula in line with modern standard practice, as the codes that govern the content of maritime curricula are based on (often dated) published literature. Even though syllabi can evolve to incorporate the most modern of technologies, certain restrictions are placed on MET institutions with regards to them being required to ask assessment and examination questions in line with a code that, largely, covers these outdated technologies. Lines of questioning regarding new technologies have in the past been questioned and overridden at the external moderation phase in South Africa, in favour of the 'outdated' printed literature that exists.

The use of computer technology that can be used as a supplementary tool (in conjunction with the printed literature) aids in placing the working principles of certain components (as depicted in the printed textbook literature) in line with both the equipment and alternative modern practices (that are found onboard newer vessels). It is often the case that the newer technologies found onboard modern vessels contain a multitude of electronic components and microprocessors, which pose difficulties when it comes to understanding the operational concepts of the components and systems that are studied. In order that the underlying theory can be placed within a meaningful and practical context in the workplace, the preference for technology that can be used as an enhancement tool for available literature is often the preferred choice.

A CBT model comprises software that is aimed towards assisting the instructors with attaining their pedagogical goals of delivering the course content to the students (Machado and Tao, 2007). CBT curricula also have the advantages of allowing for the material to be easily accessed after classroom hours (if media content exposure is required), or for courses to be run via distance learning should the need arise. The latter point is especially prevalent where study and participation are required from students whilst they are serving the maritime industry at sea. It is often a requirement to accommodate students whose companies remove them briefly during the course of their studies at the CPUT DMS, for brief sea stints when they are experiencing staff shortages.

In order for a CBT model to be effectively implemented, varying degrees of hardware development and acquisition are required by the institutions. The quality and layout of these systems largely depends upon the available funds of the institution. The complexity of a CBT system could vary from the students logging into a wireless or wired local area network (LAN) with their own laptops or tablets to access either web-based or intranet course material, or through the medium of a more sophisticated software package and fixed computer network that can also facilitate instructor-student, student-student and student-instructor communications. The latter system has the benefits of being able to project images and text from the instructor's computer station onto those of the students, so that all students are reading from the same page when need be, however, this could also stifle the students ability to progress within the literature at their own pace as the process would become more 'guided'.

Muirhead (2002) emphasizes caution of behalf of the institutions responsible for CBT tuition, in that considerable skill and expense is required in order to procure and manage top-end computer based systems. This is something that may be out of sync with the priorities of many MET institutions. In light of this, it would appear a sensible balance be adopted that best meets the goals of aiding the student's understanding of the subject matter, whilst still not placing undue demands on the MET institution itself in terms of procurement and development costs.

There are numerous forms of learning management systems (LMS) and CBT models available (both commercially, and through open-source downloads). In order to evaluate the alternative systems that are available, the various primary options have been reviewed with regards to each ones' suitability for use by the CPUT DMS. For the purpose of this study, the term 'e-learning' is to be viewed with the aim of supplementing the classroom-based activities, as opposed to providing a distance-learning platform of education that the term often describes. Whilst the option of seagoing study is currently unavailable to maritime students in South Africa, a system that is capable of exercising this option (should the environment become more favourable towards distance learning for seafarers) is preferable. It is envisaged that once the CPUT DMS converts to the three-year continuous study program that the degree programme will entail, numerous other forms of maritime education will become available for the education of seafarers. In the next section the various prominent forms of CBT programs and LMS software that are available for maritime education purposes are documented.

3.2 Computer-based education model review

In terms of developing a CBT syllabus for Marine Engineering use at the CPUT DMS, and before guiding the course from one that is purely lecture based to one that is heavily reliant on the use of updated/emerging technology, it became important that the correct blend of delivery methods and content be used. The needs of the course, from a content perspective, are required to be matched with the most suitable method of delivery to make the context and principles involved informative and understandable.

The starting point for any CBT system is the provision of information, with the CBT model using the available technology in the best possible manner to transform that information into meaningful knowledge (Georgouli, Skalkidis & Guerreiro, 2008). When it comes to Marine Engineering syllabi, the sheer volume of text that a student is required to become exposed to, can make the use of affordable handheld tablets problematic. This is largely down to the fact that very often the students prefer to study text in a paper format (as opposed to viewing text on a tablet or computer screen)[39], as they feel they can quickly and easily page between different sections of the material in order to form constructs (as opposed to opening and closing digital files). Additionally, the students can make notes and symbols that are relevant to the material, as well as highlight relevant important sections for later review.

Merrill (2002) proposed five key principles of instruction within a learner-centered approach, which can be aided through a CBT assisted model of education. These points can be listed as follows:

(1) The demonstration principle: the demonstration principle refers to the promotion of learning activities through the observance of suitable demonstrations.

(2) The application principle: the application principle refers to the promotion of knowledge acquisition through the application of new knowledge.

(3) The task-centered principle: the task-centered principle refers to the promotion of knowledge through conducting task-centered activities.

(4) The activation principle: the activation principle describes the activation of experiences or prior learned knowledge that can be used for the acquisition of new knowledge.

(5) The integration principle: this principle refers to the placement of this new knowledge that has been acquired, into the existing knowledge structures that the student had previously obtained.

The movement from the initial stage of the provision of information, through the activation of learned knowledge onto the application of this learned knowledge, can be facilitated through a process of engaging of the learner via a suitable CBT program. One method to enhance the engagement aspect is through the development of a community within the software program. This can be carried out through the use of forums, announcements, Emails, and chat facilities that have been built-in at the CBT development phase (Georgouli, Skalkidis & Guerreiro, 2008).

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[39] Confirmed from Survey 2 feedback received.

Most LMS systems incorporate a facility for community development and participation among the study participants. Participation can be either through the formalised systems already mentioned, or through the design of a CBT model that promotes other forms of discourse between the participants, with collaborative approaches that promote dialogue in the acquisition of knowledge. It is important that the CBT model in use retains the possibility for participation on the part of the students, so as to avoid the chance of any CBT model developed becoming a static tool that has limited use. The primary purpose of a CBT program should be that of making written text meaningful (complementary), and to promote participation (thus allowing for student engagement), as opposed to becoming a static supplementary course addition.

In terms of the available options for the design/population of a CBT/LMS model of education, it became a requirement to research the capabilities and deficiencies associated with the major systems that are in use today at institutions of higher learning. With this information, the reasoning behind the choice of CBT/LMS system that was introduced became clearer, both in terms of meeting the needs of the type of student that the CPUT DMS admits to the institution, and for the institution (CPUT DMS) itself.

3.2.1 Blackboard proprietary software (online option)

The first LMS to be reviewed is the current proprietary software of choice for CPUT, Blackboard. This form of LMS is used with other forms of engineering education (in a classroom context) at the CPUT main campus at Cape Town. The Blackboard LMS can be classed as a virtual learning environment, which has been created and is maintained by Blackboard Inc., to enable educational institutions to create internet-based learning programs.

In addition to the provision of the course content material, the Blackboard LMS software aids the course facilitators with the administration of the course delivery process. As of 2007, Blackboard enjoyed approximately 80% to 90% of the LMS market share at secondary school and university level internationally (Machado & Tao, 2007). Recent versions of the Blackboard suite have focused on improving the usability of the system and staying current with evolving web standards. Some of the more recent enhancements include Facebook integration, the introduction of

SafeAssign (which scans assignments for plagiarism), and improving the navigational ability from within the suite (Pishva, Nishantha & Dang, 2009). Future design trends from Blackboard are likely to see further integration with mobile technologies as they evolve further.

A study conducted by Yueh and Hsu (2008) found that very few faculty members were actually using the LMS at their disposal to its full capability. The findings showed that many lecturers were not actually assessing the students through the Blackboard platform, nor were they promoting community involvement, but rather the software was used as a tool to complement the course (i.e. the sending of e-mails, the posting of syllabi and assignments). The reason for this was that many of the options not directly linked to the provision of course content, were found to be relatively complex and time consuming to administer, a finding that agrees with the trial conducted in 2012 at CPUT DMS[40]. Research conducted by Pishva, Nishantha and Dang (2009) found that recent versions of Blackboard have become rather complex in order to include certain of these new functions and developments, and as a result of this, a rather steep learning curve is required in order to effectively administer an online course. This has the negative consequences of lecturers refraining from performing many of the administrative functions from within the Blackboard LMS, in favour of a perceived more user friendly application of their choice.

As stated, the Blackboard LMS is in use for many numerous disciplines at the CPUT main campus in Cape Town, but as yet has not been used at the maritime campus of Granger Bay, other than in the form of a brief trial conducted previously by Lambert in 2012. From these tests, it was found that Blackboard, like all good LMS's, has the ability to support the classroom teaching and learning process, facilitate discussions and deliver and grade assignments, on a wide variety of electronic devices. However, many prohibitive challenges were encountered due to poor information technology (IT) support levels encountered at the DMS campus, where at times the students could not login to the course content for extended periods. This required service calls to be logged to the IT helpdesk on the main campus, and a technician to be dispatched when available, a situation deemed unacceptable when the waiting time was a matter of days, for a course that required daily participation.

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[40] Blackboard version trialed for Marine Engineering at CPUT DMS by Lambert (2012)

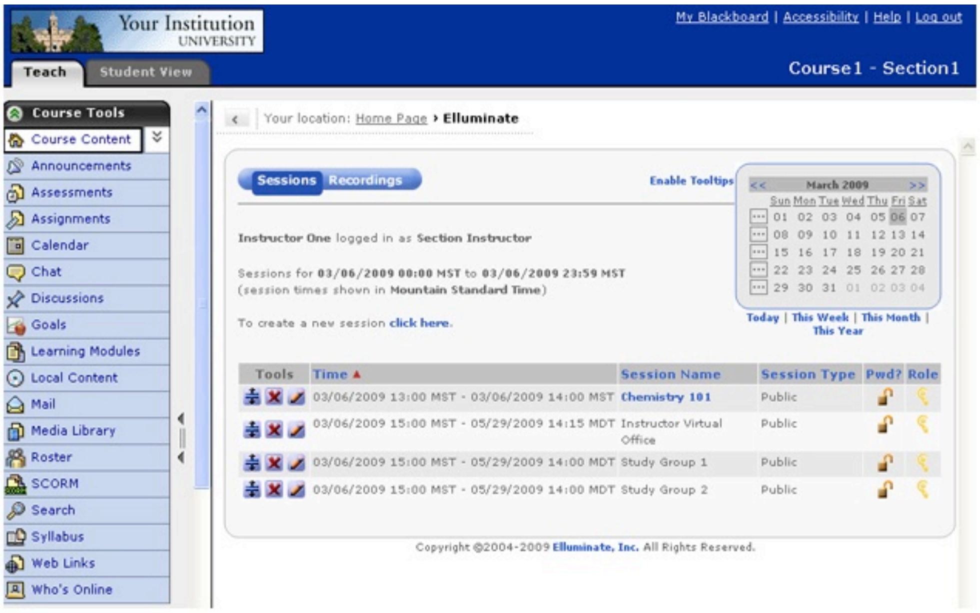

Figure 8: Blackboard LMS example (Blackboard Inc.) image

In terms of ability, Blackboard has been proven to be a very competent platform, however the infrastructure at CPUT DMS resulted in longer download times than were expected in order for the students to have access to the posted digital media. The time required to open the different animation files, images, sketches and video clips that accompany the text component resulted in many students refraining from opening them and thus not enjoying the full spectrum of media at their disposal. Additionally, when content was required to be accessed after hours, the internet-based nature of the LMS meant that the data transmission costs to retrieve the files could become an unnecessarily prohibitive financial burden for many of the less affluent students.

Many of the students at CPUT DMS stem from out of town, from rural areas, or are from countries outside of South Africa. These students often attend campus on a student bursary, whilst residing at student accommodation for the duration of the six-month semester program. As a result of this, a large portion of the student body do not have access to the internet, and thus would find themselves disadvantaged in relation to their fellow students who would be able to access online course material after university hours.

The SafeAssign component of the Blackboard LMS is not required for a Marine Engineering course at the CPUT DMS, as the requirement to deliver original writing is above the level at which these courses are conducted (being a diploma programme). Furthermore, assignments are conducted in a manner where students are required to explain in length their understanding of the course work, as opposed to filling in singular words and phrases for online grading. The lecturer is required to determine a mark allocation for the student, in a manner that a pre-programmed format of assessment criteria could not accurately ascertain. For this reason, and in order to fulfill the mandatory requirements of the externally moderated assessment format as stipulated by SAMSA (the assessments are hand written to include the required sketches), hand written assessments would still be a requirement even if online assessments were to become a possibility.

The final observation from this trial period that was conducted in 2012 for the Marine Engineering programme was that in order to open a file (text, sketch, animation or media clip), navigation away from the existing page was required, followed by a delay while the particular item loaded. This was deemed to be distracting to many of the students, as the process was disruptive to one's thought process. Finally, the menu format that the Blackboard software used was not ideal in terms of allowing the students to grasp an overview of what each individual chapter contained, as it was severely lacking in graphical content until the individual files were opened up.

In summary, and in light of the restrictions placed by the SAMSA external moderation process, the Blackboard LMS would be able to deliver course content, but research conducted would have to concur with the findings of many other lecturers in that other course components (i.e. the SafeAssign function and online assessments) would not be required. In an environment where (a) the IT support was better, (b) if the student internet access after hours was not the critical issue that it is, (c) if data transmission costs were lower, and (d) if data transmission speeds were faster, the Blackboard LMS would likely become the LMS of choice for the DMS. However, given these obstacles, the Blackboard LMS has to be discounted as a LMS for Marine Engineering use at the CPUT DMS within this particular environment.

3.2.2 Moodle open-source software (online option)

The second LMS that was reviewed is that of Moodle. A version of the Moodle LMS was downloaded for perusal for the purposes of this study, after being initially recommended by WMU as a system that was capable of fulfilling a similar function to the Blackboard suite.

Moodle is an open-source LMS software program that is available on a free download, requiring a platform running Linux, Apache, MySQL and PHP, often termed LMAP. The software is widely used at many higher education institutions, and is fast gaining in popularity as an educational tool. Moodle is stated as being more user-friendly than the Blackboard platform, as it can easily be configured and can be readily adapted to suit the users requirements. However, as the software is open-source, assistance in the form of product support can only be obtained through online user forums as opposed to the support mechanisms that accompany proprietary software models (Bremer & Bryant, 2005).

Beatty and Ulasewicz (2006) believe that as opposed to being a disadvantage, this fact actually places Moodle favourably in relation to the Blackboard platform, as due to the software being open-source, there are many new developers around the world working to build new LMS components. In terms of support for lecturing staff, Machado and Tao (2007) highlight this as a problem associated with the Moodle platform, as there is a need for the requisite knowledge to successfully implement the software; an issue not required of proprietary software forms.

Figure 9: Moodle LMS image (Moodle.org) image

In their research regarding student preferences between Blackboard and Moodle, Machado and Tao (2007) found that the preference from students was towards the Moodle platform, citing the ease of use and the organisational aspects of the material layout. When comparing the Blackboard platform with the Moodle platform, certain key differences can be noted that appeal to many users, which can be described as follows:

(1) The Moodle interface displays the same view to that which the course facilitator sees, with the only addition being a suite of editing tools along the right of each course element. In comparison, the Blackboard platform looks completely different to the lecturer in comparison to the content web page as viewed by the student.

(2) The Blackboard organisational aspect of the course content follows a 'form' design, where all elements of the same type are grouped together in a bundle. The grouping allowable within the Moodle environment caters for grouping of different elements by course topic, or by calendar period, whichever is preferred. In this way, different forms of material can be viewed together, making the finding and opening of course content available from the same section of the computer screen. This has the effect of becoming a more 'user-friendly' student environment.

There are certain advantages that are noticeable when comparing the Moodle LMS to the Blackboard LMS, which primarily include factors such as its ease of use and customisability of the Moodle platform, the fact that the software is constantly being upgraded, and the greater amount of flexibility that the Moodle suite is able to offer. Possibly, one of the greatest attractions of the Moodle system is the system's ability to record everything that the students do. In this way the lecturer can see how many times a student has accessed a particular source within the course material, and ascertain participation levels on the part of the student.

Moodle has similar drawbacks to Blackboard in a South African context however, as Moodle requires an internet connection (which again excludes many students from accessing the system after hours), and as internet-based systems require the files to be downloaded, it can become a hindrance in terms of data transmission speeds and the data transmission costs involved for the students after hours. A further downside to adopting the Moodle LMS platform stems from the fact that as CPUT has adopted the Blackboard platform on the main campus as their LMS of choice, and have subscribed to the proprietary software and support mechanisms afforded by Blackboard Inc. While other forms of LMS are allowed at the CPUT DMS (lecturer preference), it does mean that the use of any other LMS (and associated cloud hosting costs) would be at the cost of the individual lecturer involved. Crucially, should alternative LMS's be used at the CPUT DMS, any form of IT support or funding would not be forthcoming from the institution. Finally, (a) the setting up and management of the course content, (b) the student access database management and (c) the course management itself, becomes a very time consuming exercise (although the same can be said for the Blackboard suite). If the time required to manage the system should become excessive, it can become a factor that can detract from the process of imparting knowledge, which should be the key priority of the CBT or LMS in use.

Both the Blackboard and Moodle systems requires the students to log in to the LMS, which provides for a more controlled and secure environment. With regards to the user interface, and the experience that the student will have with Moodle as opposed to Blackboard, an improvement can be noted with the Moodle platform. Moodle was shown as being graphically more appealing, as it has the ability to place course context in a manner that is more easily retrievable.

When it comes to choosing a LMS/CBT model, the selection ultimately comes down to the correct choice for the job, in order to make the delivering and comprehension of the subject material a smooth process, and to ensure student participation. The two LMS options described, the Blackboard platform (proprietary) and the Moodle platform (open-source), or indeed similar equivalent software packages of this nature, will competently be able to deliver content and manage the learning experience of the students in a classroom environment. It remains a question of their suitability in a South African context (in terms of after hours internet access) and from a maritime context (accessibility to course content at sea given the company imposed data transmission limitations that exist).

Before looking at residence based CBT models, which can dramatically reduce the need for excessive amounts of data to be downloaded, a further internet-based model will be described that can provide the option of a content management system and material reference source for students.

3.2.3 Independent purpose built software (online option)

Early on in this study, an independent CBT model of education was considered, minimally developed and briefly uploaded in order to ascertain the viability of an independent file storage system. This was trialed on a stand-alone server, in the form of a website (external to CPUT), and administered by the lecturer. The idea behind this trial was to create an online data storage location and file-posting platform. As this design did not incorporate a login access, students who wished to continue their studies at sea could do so without being enrolled at CPUT, thereby enhancing the notion of lifelong learning as opposed to being a purely semester based offering.

The reasoning for the formulation of an independent CBT system was in line with the thinking of Mott (2010) who believes the following with regards to the administration of an institutional LMS:

(1) The organisation of the Blackboard LMS in use at CPUT main campus is designed and configured around the course semesters (which are time based), meaning the content requires continuous attention as to prevent it from vanishing from the system at the end of the course.

(2) The content and the layout that the courses adopt are created by the lecturer. As a result of this, the LMS can become very centered around what the lecturer wants with little provision being provided for student initiated learning, or input from the part of the student other than participation.

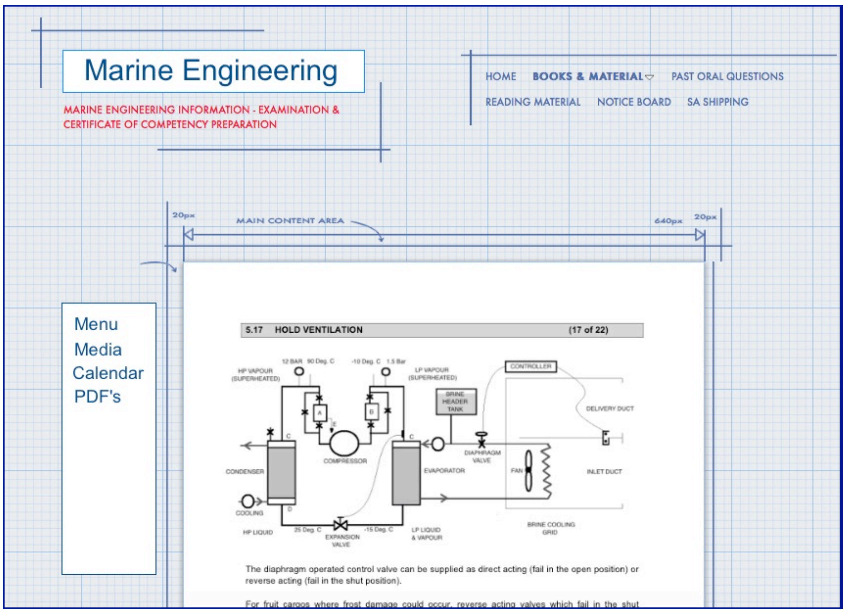

Figure 10: Stand-alone website CBT model (marineengineering.co.za) image

Benefits of a stand-alone model are largely related to the limitations that exist with the current levels of CPUT IT support, and the lack of computer hardware and software that exists on the campus. An independent website would be a cost-effective option for content management, however any devised system would need to include database hosting so as to manage and limit access to students only through a login function, if it were to be used for the purposes of running a course.

While a stand-alone system would greatly simplify the administration of the course, and avoid the need to use the disruptive CPUT DMS infrastructure and support mechanisms, the requirement for internet-access on the part of the students again cannot be ignored. In a similar manner to the two previous systems described, the data transmission costs and download speeds would become a negative constraint of this model. A further downside of a stand-alone system that resides within a privately owned model (external to the institution servers) is that the program's longevity only exists while the lecturer is maintaining the content and hosting thereof. Should the lecturer leave the particular institution, the likelihood that the system ceases to exist becomes a distinct probability.

A system of this nature may have benefits through being an additional online Marine Engineering knowledge literature storage facility that runs in conjunction with the institutional LMS. In this way it is able to provide for additional information sources as required by the students. In comparison to the Blackboard and Moodle platforms, a stand-alone privately managed system would be a less competent program unless professionally designed and managed, and would likely not prove a cost effective option in terms of the design element when compared to proprietary software (which is an institutional cost) or open-source (which accrues hosting costs only).

The final system that was investigated in terms of being able to become a content management system for Marine Engineering use, was the only form of CBT model that did not require an internet connection after hours. As a result of this, the model is appealing in terms of its usability in a South African context, where inequalities still exist among the student body in terms of their demographical backgrounds and the resources available to them.

3.2.4 Concept mapping open-source software (computer-resident option)

As mentioned in the preceding section, in a South African context, taking both the university and student constraints into account (Muirhead, 2002; Singh, 2003), the outcomes from the initial round of data collection surveys' cast the online option in a negative light. The initial student information data that was collected[41] confirmed the belief that internet-access after university hours was unavailable for many of the students. In comparison to European data transmission norms, CBT data management in an online format would only work for all the students when in a classroom environment, with students reverting to textbooks and class notes after hours as a result of these obstacles.

A further concern that was confirmed through survey information extracted, was that the data transmission size limitations that existed onboard ships at sea would prohibit the execution of an online study course for seafarers serving the industry at sea.

[41] Survey 1 (Appendix).

One appealing way to circumvent the need for online course hosting can be found in the form of the open-source university initiative software program called CmapTools. This concept mapping computer software program has been successfully used as an educational tool in the past, and was trialed for use in a maritime context at the Singapore Maritime Academy (SMA) to run their steam conversion course for Marine Engineers. CmapTools is offered as an open-source, freely downloadable program that has the ability to be run either online, over a classroom network or on individual stand-alone laptop computers. CmapTools offers a flexibility that is not found within an institutional LMS, and provides a cost-effective alternative to data transmission over the internet.

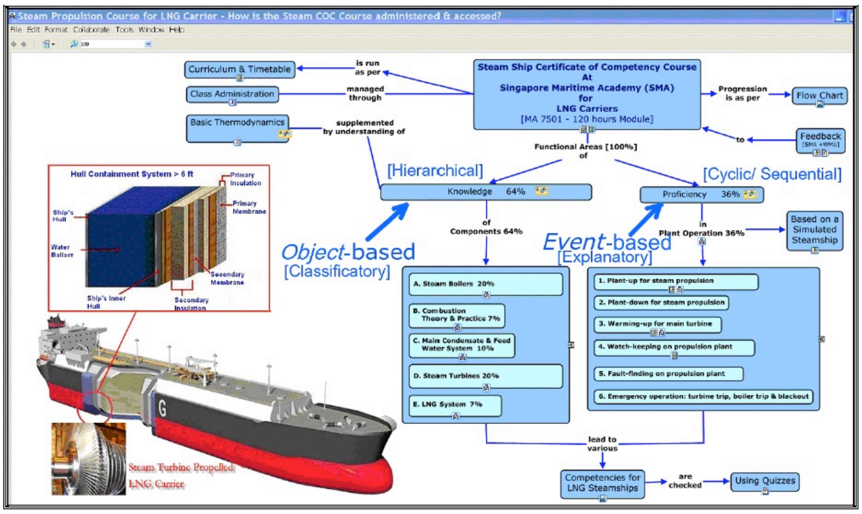

Figure 11: CmapTools CBT model (Chatterjea & Nakazawa, 2008) image

Taking the needs of both the student and the institution into account, a review of the concept mapping educational software model indicated that this form of CBT content management program, could address these key concerns. Being highly flexible, the content layout and course management can be tailored to address these restrictive factors in the following ways:

(1) *Concern: Limited internet-access capability for many students (after university hours)*

In order to address this challenge, the CBT software can be implemented to be a resident-based model, meaning the information could be loaded onto the students individual laptop's hard drive for the duration of the course (and retained afterwards if required by the student for lifelong learning purposes). This option not only cuts down on the data transmission costs on the part of the students, but also speeds up the time requirements for loading and displaying the course media content. The importing and exporting functionality, which can be used for sending and receiving files between the lecturer and the student, is done via a very small Email attachment. This Email transmission could be done either from home, or the next morning when the student attends class (for those without an internet connection).

(2) *Concern: Limited data transmission size requirements for students at sea*

Based upon the principles of how data within onboard planned maintenance systems is managed, use can be made within the CBT software design for information additions (receiving files) and student participation (sending files) via limited size Email attachments. Weekly completed assignment maps can be exported in PDF format as an attachment, and sent to the lecturer for viewing and marking as required, where the student can then receive feedback via Email. Literature, in the form of handouts, can be periodically mailed to the students, who then import the attachment into the "MyCMaps" folder in their "documents" once received. This information will then become available to the student through the CMapTools program the next time they access the program, and incorporate the linkages required to the material.

These Email attachments are typically around 500 kilobytes in size, and are therefore acceptable to just about all shipping companies in terms of satellite data transmission limits that they may impose upon the seafarer for the sending and receiving of Emails.

(3) Concern: Perceived rigidity of the Blackboard & Moodle platforms

One of the strengths of the CMapTools platform remains its fluidity when used as a CBT model of education. The contents and layout of the syllabus are easily modified to suit the particular preference of the students. Once accessed, the files can be amended, assignments can be completed and these files can be Emailed by the students for assessment, if need be. In this way, the students are able to actively participate in the completion and building of the concept maps and assignments in a manner that is able to better their understanding of the subject matter. In essence, the system becomes a living knowledge document that can be built upon as new ideas, constructs and concepts arise during the course of their studies.

A further benefit is that an 'often unreliable' component is removed from the CBT delivery chain, namely the IT support and data hosting requirements that are required with an internet-based CBT program. This allows for the system to be simplified and managed easier by the lecturer for the duration of the course, without reliance upon a third party for vital services.

The versatility offered by the concept mapping (or 'mind mapping') design allows for an educational program to be configured in a content management format, and while the software allows for the importing and exporting of files, it is important that the negative aspects be highlighted. The facility does not exist from within the software for the monitoring of student activity for example, nor is provision allocated for chat forums and notice boards; components that are part and parcel of the prominent LMS's on the market. However, even though student participation cannot be viewed in terms of how often a particular student accessed the software from within a concept-mapping environment, the requirement for the students to submit the completed maps and assignments compensates for this omission to a certain degree.

If the primary aim of a CBT/LMS model is the provision and hosting of the subject content, whilst allowing for the students to actively participate in developing their understanding of the content, then building a CBT model through a concept mapping design framework is able to provide a viable alternative to the methods mentioned previously. In the following section, the use of concept mapping within education is discussed in more detail.

3.3 Concept mapping as an educational tool

Concept mapping originated in 1972 from work conducted by Joseph Novak, who set out to conceptualise the understanding that children have with regards to science education. In order to represent his findings, he developed a graphical mapping tool that has since spread to other areas of academia (Novak & Cañas, 2006). Concept mapping comprises a structure of labels that are used to identify the concepts, with linkages formed between the concepts in order to develop meaning and aid the understanding thereof. A pair of linked concepts comprises what is termed a proposition, with the mapping process facilitating the linking of these propositions to give the student a 'personal definition' of the subject matter (Novak & Cañas, 2006). These formulated propositions reflect the understanding of the student, with the validity of their understanding being open to scrutiny (Hay, Kinchin, & Lygo-Baker, 2008), a process that allows for the maps to evolve as a deeper understanding of the subject matter develops.

Concept mapping aids in the linking of new material with a students existing cognitive knowledge, and should be constructed in a manner that is able to represent one's individual perception of the subject matter, as opposed to knowledge and fact reproduction (Kinchin, Hay, & Adams, 2000). Higher-order thinking and problem solving requires the type of organisation that domain-specific concept mapping can deliver. As the map represents the organisation of the subject knowledge, the recall of such knowledge is made easier, and as a result of this, the cognitive load required for the learning process is reduced. Concept maps used in this way also highlight connections between aspects of the subject matter that had not previously been noted by the students, which is particularly useful when trying to conceptualise a difficult or unfamiliar task.

Types of concept maps

Concept maps can be used in order to fulfill a variety of uses to those participating in their use. Developed as an educational teaching and learning tool (from initial mind mapping origins) they provide the students with a scaffold picture of their understanding of the subject matter. In this process of clarifying clutter into a more easily understandable format, concept maps have the ability to improve the learning experience for the student (Carnot et al, 2003).

Concept maps are widely used in teaching and learning as an organisational tool, providing a subject overview of the material that is to be learned. The most meaningful outcomes that can be achieved through the use of these organisational maps is when new items that have been learned are integrated with existing cognitive knowledge domains through the relationships formed within the maps. They can be utilised prior to the start of new material being presented to showcase how new material can integrate with existing knowledge. This can either be done during the class in the form of a subject overview, or alternatively, as a review mechanism once the lecture has been completed.

Through a concept mapping process, the form of instruction becomes ‘conceptually transparent’ to the students (Novak, 1998). Different levels can be constructed within a concept-mapping environment to move from the macro viewpoint through to a micro perspective, thereby showing a greater level of detail in areas that require more precise information. In this way, the size of the map can be contained, thereby limiting the quantity of information viewed at any time

However, concept maps that are compiled solely by the facilitator (despite saving on lecture time) has the possibility of promoting a more passive response to the work on the part of the student, resulting in less effort being put in towards the understanding of the content. There have been three major concept map design philosophies, which have been devised with the intention of deriving the most value from the resources, without producing any form of cognitive overload (Chang, Sung, & Chen, 2002). These design philosophies can be described as follows:

(1) The first of the design philosophies to be reviewed is that of ‘scaffolding’. With this design, varying levels of assistance can be provided, and this assistance can then later be withdrawn as the learner’s ability progresses. Completed expert maps can be phased out and lesser complete maps, or skeletal maps as they are sometimes referred to, instilled in their place. As time progresses, and understanding develops, the students are able to form linkages within the material and construct maps on their own without extensive aid.

(2) The second approach to concept mapping can be referred to as that of ‘completion’. In this case, the learner is provided with some form of guidance, or partial solution, with which they need to progress from the given situation towards completing the intended outcomes. In essence, the students fill in the blanks, or missing linkages, to derive the solution to a particular task. Through

varying the level of initial assistance, the degree of completion required can be altered, thus affecting the effort required on the part of the student.

(3) The third approach proposed by Chang, Sung, & Chen (2002) is aimed towards bridging the divide between reading and constructing maps. They propose a system of ‘map-correction’, whereby expert maps are provided with approximately 40% of the material incorrectly linked or labeled according to the text content. With these maps, the students are not only required to understand the process involved, but they are also required to think critically about the faults and incorrect linkages within the subject material. Through this process, a deeper level of thought can be facilitated if the maps are thoughtfully composed; which was a hypothesis that was backed up by the findings of their research.

In terms of meeting the outcome objectives of concept mapping as a teaching and learning tool, the process ultimately needs to accomplish the following objectives: (a) the measurement of prior knowledge, (b) the presentation of new material within the context of this prior learned knowledge, (c) the engagement of the student in making sense of this new knowledge and the demonstration thereof, and (d) the final measurement of the change process (Hay, Kinchin, & Lygo-Baker, 2008). If concept mapping is to be used successfully as a regular part of classroom tuition, it needs to be able to be merged with the favoured tuition practices and methods that exist. To integrate concept mapping into the daily classroom activities, both the course content delivery needs to be done in line with the layout of the concept maps (as constructed), and the learning methods that can make the maximum use of learning within a concept-mapping framework need to be considered. One of the primary learning methods that will enhance the manipulation and construction of concept maps is the collaborative learning process.

Another design element that can be incorporated into a concept-mapping syllabus that can aid students in clarifying information that is unfamiliar to them, is that of a scaffolding design process. Through the extensive use of scaffolding, extensive support (and later fading) mechanisms can be built into the concept map design of the CBT model, so as to provide a structured, guided approach to the learning for the lesser experienced students among the groups.

3.3.1 Scaffold learning within a concept mapping environment

In tests conducted during the course of their research, O'Donnell, Dansereau & Hall (2002) found that concept map users were able to recall more information than were other students, especially where key points are concerned. Additionally, the research showed significant benefits for those students who naturally favour a visual learning style approach. Research undertaken by De Simone, Schmid and McEwan (2001) showed that students use concept maps in three ways, namely (a) for basic comprehension, (b) creatively, which resulted in deeper comprehension of the subject material and (c) incorrectly, due to factors including time constraints, difficulty comprehending the material, and through interference with other learning strategies favoured by the student.

It has been found that improvements can be made by students with poor English language ability in the comprehension of scientific text, when concept maps were used Amer (1994). Findings of this nature are relevant to the CPUT DMS, as due to the diverse makeup of the student body, the majority of the students have weaker English language skills when compared to the proficiency they enjoy with their home language. These findings tie in with those of De Simone, Schmid and McEwan (2001) who found that concept mapping and collaboration complement each other in a classroom environment. While the process of concept mapping aids in the representation of ideas and the externalisation of internal thoughts, the collaborative process of dialogue and discussion that takes place within the classroom, allows for the sharing of those representations.

Knowledge maps[42] can be used as key sources in the acquisition of knowledge. They can be used to aid the processing of text, and can offer assistance in the organisation of knowledge to make information retrieval easier. In this way, due to enhancing the relationships that exist between constructs, they can reduce cognitive loading on the part of the student (O'Donnel, Dansereau & Hall, 2002). Experiments that have been conducted to examine the effectiveness of a graphical, well laid out system in comparison to one that was less defined in terms of its organisational aspects, has

[42] Knowledge mapping makes use of node-link representations in which concepts are located in nodes, which are connected to other related concepts through labeled linkages (O'Donnel, Dansereau & Hall (2002).

shown favour towards graphical scaffolding design elements (Wiegmann et al., 1992). These three experiments that were conducted can be summarised as follows:

(1) For the first experiment, two maps were developed that were similar in form and relations in terms of the content. One type of map was designed according to Gestalt[43] principles of symmetry, focusing on how people recognise form and patterns. Within this design, similar material content was grouped and the continuity of information was recognised. The other map was in the form of web content, where gestalt principles were not used. In this experiment, the students using the gestalt-designed maps fared better than those students within the web based form groups.

(2) In the second experiment, students were split into two groups, with one group studying from information presented within a single map, and the other group from information contained within a series of stacked maps. The findings from this experiment showed that those students studying from a single map fared better in terms of the recall of knowledge than those students using the series of stacked maps.

(3) The final experiment involved the compilation of similar map forms, but utilised different methods of illustrating the relationships that exist between constructs. Linkages were either illustrated as simple straight lines, or embellished with labels, arrowheads and configurable information. The outcomes from this experiment showed that those students with lesser verbal ability fared better when their maps had plain lines, and those with higher levels of verbal ability performed better when the linkages were embellished.

In their research, O'Donnel, Dansereau & Hall, (2002) state that if maps do indeed reduce the cognitive load on the part of the student, they may be very effective when used in a multimedia or hypermedia environment as a support mechanism for student learning.

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[43] Gestalt: a German word for form or shape. The idea that natural systems and their properties should be viewed as a whole, not as a collection of parts.

Classroom studies have been conducted in the past to determine the effectiveness of concept mapping in fulfilling set criteria with regards to the model and course being delivered. Whilst most of the studies were conducted at school level, certain key studies have been posted at undergraduate level, and one known previous study has been done that involved the maritime industry. The details of these are laid out in the section that follows.

3.3.2 Classroom studies using concept mapping principles

Previous studies involving the use of concept mapping in education that have been reviewed for this study, date back to 1985. The following data has been retrieved from a report compiled by Carnot et al. (2003), which details the process that 16 institutions implemented to study the effects of the use of concept mapping in one form or another (Appendix 2). This list has been updated with information derived from a study that has been completed involving the maritime industry in 2008 (Chatterjea & Nakazawa, 2008), and includes data from this particular study that ran between 2014 and 2015.

At a school level, 10 studies have been analysed that had stated sample sizes ranging from 51 to 808, and stated durations of between 3 and 10 weeks. The number of assessments that was used to determine the outcomes ranged from 1 to 8. With all of these studies, the purpose was to test the effectiveness of the concept mapping system in comparison to other forms of instruction that was provided (in different guises).

At an undergraduate or college level, 6 studies have been analysed that had stated sample sizes ranging from 20 to 186, and stated durations of between 1 session and 8 weeks. The number of assessments that was used to determine the outcomes ranged from 1 to 2, although in one of the studies, the assessments were replaced with structured interviews. Again, the purpose of each of these studies was to test the effectiveness of the concept mapping system in comparison to other forms of instruction provided (in different guises).

<u>Classroom studies within the maritime sector</u>

Within the maritime sector, two studies have been conducted involving Marine Engineering students at a management level (including this particular study). The sample size of the study conducted at the SMA was 37 and at CPUT DMS, 118. The duration of the course offered at the SMA is not stated (steam conversion course), whereas the study at CPUT ran for 3 semesters (18 months). A total of 6 assignments were analysed for each of the 4 cohorts of students (24) while the CPUT DMS study analysed 72 written assessment outcomes over the period under review.

The primary purpose of the SMA study was to develop, implement and test the effectiveness of the course offering.

Novelty of the CPUT study

The novelty of the study conducted at CPUT DMS is down to the fact that it is the only known study that has been conducted at this level (over an extended period using a fairly large sample) that has been specifically tailored to address the identified challenges facing the sample population. Novak believed that the use of technology could aid developing countries to compensate for a lack of resources (Novak & Cañas, 2004), and it is this belief that has forged the purpose of the study.

The concept mapping tool that has been developed over the 24 month trial period (initial 6 month build period and 18 month sequential development thereafter) is also unique, in that it is the only known method that allows for students to be connected at sea and study Marine Engineering, without the need for an internet connection. Uploads and downloads via remote data-restrictive satellite connections (as found at sea) can be done via very small Email attachments that are imported or exported into and out of the CMapTools software program. This allows for students to attend classes when on shore leave (partial attendance, negating the need to take unpaid leave), or to study through distance learning should that occur as anticipated when the CPUT DMS three-year degree programme commences in 2018.

3.4 Hardware and software requirements analysis

After researching the available LMS/CBT options for use, it became apparent that the only system that could retain the desired fit between the institution (CPUT DMS) and the student (as stated by Muirhead, 2002) would be the open-source, resident-based model CmapTools. As a university initiative, the Institute for Human and Machine Cognition (IHMC) has developed the CMapTools software as a freely distributable open-source model that is designed for use with various operating systems. However, at the time of development of this particular study, not included in the hardware options were handheld devices and tablets. This was because it was originally felt that the viewing of maps on smaller devices was considered by IHMC to be defeating the object of a viewable map[44]. Windows based computers that can converted into tablets can be used, and have been tested during the hardware and software trials for this study, however the small size of the navigation buttons on smaller devices makes selection of the desired functions problematic.

Concept mapping development at CPUT

For this particular study, the students were required to bring their own laptop computer for use in the classroom (if they had one), or alternatively their sponsors were required to supply them with one to attend class with. The reason for taking this decision was (a) a lack of resources, infrastructure and IT support at the CPUT DMS necessitated this and (b) the students would then be able to have all the course information and media files available to them after hours without the need for an internet connection. As the students partaking in this study were all at a senior level (S3 and S4), the initial surveys conducted showed that this request could be accommodated on the part of the students. Initial survey results[45] indicated that problems will be experienced with laptop ownership at the more junior levels (for private students), and this would require addressing should the CBT model be implemented for the Officer of the Watch (EOW) students. In this regard, discussions have taken place regarding the purchase of entry-level laptops, or the adoption of a laptop hire program in the future, should the outcomes from this study warrant migration towards paperless study syllabi at the CPUT DMS.

From February to June 2014, the syllabi were compiled in a digital format and initially comprised about 2,200 files from various sources, including text, sketches, images, photographs, animations and video clips. At the start of the classroom study phase, the CMapTools program was loaded onto the student's computers at management level in July 2014, with no problems being reported in terms of software compatibility or laptop microprocessor ability to manage the course content. Whilst this open-source

[44] This changed in 2015, with the introduction of CMapTools versions for tablets and handheld devices.
[45] Survey 1 (Appendix 1).

software is available as a free download, the CD and associated rights to load the software for educational purposes had been purchased so as to provide a tool for the students to load the program without access to the internet (which would otherwise be required for downloading the software). Once loaded, all the media and text viewing applications that were configured using freeware (Adobe PDF viewers, VLC media players etc.) were loaded. This meant that the additional costs to the student in terms of software purchases were zero. Also trialed was the OpenOffice software suite (available as a free download), which proved capable of running the standard range of software applications required of a course of this nature.

As stated, once the software was installed on the students' computers, the course files were loaded in a single folder (for accessibility) and desktop links were created for the exporting of the required assignment maps as part of the course requirements. A batch folder can have files added to it at any stage by simply dragging received Email files into that folder, and either creating the necessary link from within the program or using the existing blank links created within the design for this purpose. From here the files could be updated as required, so that the CBT model could remain fluid in terms of information relevance and could be continually updated as the courses progressed. Each student received a copy of the backup files on data DVD at the start of each course, where they could reload files should any difficulties be experienced through laptop theft or computer hardware problems.

It was always the intention to keep the data size within manageable levels, so as not to disadvantage any students who owned entry-level laptop computers. The data size was in the region of about 2 gigabytes for the four subjects, which did not pose a problem in terms of computer memory space availability on the part of the students. Should available space become an issue, it is possible to run the executable files from an external hard drive or flash drive, whilst the files are read from and written to the external drive. This option however does require certain changes to be made to the computers port configuration in order to find the required files, and as such, this option was left available should hard drive size restraints become a challenge in the future as the syllabi evolve further.

The total cost to the institution for implementing the CBT model was nil, as the funding for the classroom hardware (TV, software purchase, desk plug points, computer and sound system cabling) were borne by Lambert as part of this study. The total spend was in the region of R 20,000 (or $1,430 at an exchange rate of 14:1). The cost to the students was in terms of the laptop acquisition (if they were private students and did not already possess one). New entry level laptop computers in South Africa retailed in 2014 for about R 4,000 (or $285 at an exchange rate of 14:1). The benefits of the open-source model can be seen through the follow-up costing, as there are no associated proprietary rights costs, no IT staff requirements and no data hosting costs other than the transmission of basic Emails during university hours. With each student having the CBT syllabi loaded on their own portable laptop computer, there were no students who could be disadvantaged after university hours as a result of not being able to access the course data.

The portability of the CMapTools programme can also be used to expand the CPUT DMS course offering to include seafarers who wished to partake in maritime studies while serving the industry at sea. While seagoing study is not available to seafarers at present, the flexibility of the CMapTools software package has shown that it can easily be accomplished should the stance towards seagoing study change in the future within South African maritime circles.

3.5 Distance learning in maritime education

As raised in the preceding section, the loading of the software and course material in this manner has the ability to allow students freedom to access the course material as they desire, and to participate through the importing and exporting functionality embedded in the program. Many CPUT DMS students have enquired in the past about doing a large portion of their studies whilst at sea, as private students often experience difficulty with regards to taking six months off work to complete the next phase of their maritime studies. This usually entails the students taking unpaid leave for six months, or signing extended contracts to pay back their employers through future extended sea service.

According to Larreamendy-Joerns & Leinhardt (2006), one of the methods whereby online courses should be tailored is primarily aimed at the location of the target student population relative to the institution. This is especially true in terms of the maritime industry, in that the target student population is likely to be spread around the globe, either being at sea or on leave. The difference to land-based student populations is that very often at sea, the means of communication with land is often restricted in terms of connectivity and data transmission allowances.

With regards to studying while at sea, the challenges with regards to competing alongside students on land places both the seagoing students and the industry in a distinct disadvantage, unless the associated software is purposely constructed to compensate for the needs of the industry in this manner. Currently distance learning in the maritime industry in South Africa is under review, as to whether or not to allow for the development and implementation of a distance-learning syllabus as a method of tuition. Given the fact that it is possible to study for a postgraduate degree whilst serving at sea (as was done by Lambert from 2009 to 2012), one has to question why a distance-learning CBT model of education has as yet not been implemented for use by the maritime industry. This would greatly aid those seafarers wishing to further their seagoing qualifications, whilst actively serving the industry offshore (whilst being in the appropriate environment).

The hesitancy towards allowing universities to conduct distance-learning courses comes from the fact that the University of South Africa (UNISA) caters solely for distance-learning studies. Any other institutions in South Africa offering distance-learning tuition would seen to be in conflict with UNISA. However, it is possible that courses can be run according to blended learning principles, whereby a large portion of the studies can be conducted at sea, with the students then attending certain classes when they are on shore leave.

One of the often cited challenges in this regard is that a Marine Engineering syllabus contains a substantial amount of imagery, and would thus be naturally taxing on the allowable data transmission limits for may seafarers. One way to circumnavigate this restriction is to follow the model with which seagoing machinery planned maintenance systems have been developed and successfully implemented onboard ships. Planned maintenance system data usually remains resident on a shipboard computer (server) and gets updated daily through exporting and importing small Email update attachments.

Of the LMS/CBT programs mentioned within this segment, only the CMapTools model is able to carry out this function adequately, as the content remains resident, while the assignment mailings and correspondence gets carried out through small PDF attachments (for both importing and exporting of data) via Email. In this way, the data transmission sizes will remain within company-imposed limits of satellite data transmissions in order to limit the costs involved.

With the rapidly changing technologies that are available to seafarers, coupled with the need of the maritime industry in South Africa to meet the president's stated aim of developing a maritime economy, a review of seafarer education in the country will hopefully place distance learning for mariners in South Africa in a favourable light in the future.

Summary

The reasoning behind looking at different computer-based options available was to determine whether or not the preferred choice was the best choice given the environment in which the study has taken place. The next review that was conducted was to look at the different teaching and learning practices that are used by MET institutions in South Africa, to ascertain the possibility of incorporating suitable best-practice ideas into the developed model.

In addition to gathering information about MET institutional practice in South Africa, information was also sought from various stakeholders within the South African Marine Engineering industry, as to what could be done to improve seafarer education. These findings are explained in chapter 4.

CHAPTER 4

MARITIME EDUCATION REVIEW

Introduction

The MET review of educational practices started by looking at the how the concept mapping course that was introduced at the Singapore Maritime Academy was modeled. The reason for this choice is that this institution was (a) used as a 'developed country' best-practice benchmark for the purposes of this study and (b) it was the only known MET institution to have used concept mapping for maritime training use. Following on from this review, this chapter looks at the status of MET in South Africa, in different forms, to ascertain which practices (if any) could be used to develop a CBT model for the CPUT DMS.

It was deemed necessary to detail the different environments in which these studies were conducted (Singapore and Cape Town), before commencing a review of the MET institutions themselves.

4.1 Comparison of MET methods in South Africa against the CmapTools model implemented at the Singapore Maritime Academy

One of the biggest challenges that required addressing in a study of this nature came about as a result of the fact that the environment in which the SMA operates is completely different to that in which the CPUT DMS operates. Concept mapping was initially introduced in a MET setting in Singapore, and as a result of the resources available to them as a developed nation, few challenges were mentioned in the short-duration study that took place. However, with South Africa being classed as a developing country, fewer resources are available to the students at the CPUT DMS, both from an institutional perspective (classroom resources) and on the part of the majority of the students (personal constraints). Many of the students that get admitted to the CPUT maritime study stream, stem from disadvantaged communities within

South Africa. These students often acquire a bursary to study, and are selected in order to develop the skills within certain regions of the country that are deemed to require development.

Further challenges are faced as a result of the poor academic state of South Africa's secondary education system, which serves as a feeder system for the institutions of higher learning. With CPUT stating their desired aim to go completely paperless in the near future, questions were initially asked regarding the ability of the students to successfully migrate from a paper system that they have become used to, towards one that is heavily focused on computer use. As mentioned, many of the students at CPUT receive bursaries to pursue a career in the maritime industry in the form of social development projects, and therefore, for a large portion of these students (who often are from rural origins within South Africa) computerisation for educational purposes is a completely new concept for them.

Even for those students that were fortunate enough to grow up with technology, it is prudent to ascertain to what degree those technologies have been put to positive use (i.e. education) as opposed to entertainment purposes (i.e. social media). Much has been said about today's generation of students being computer literate and up to date with the latest technological trends, however, with the introduction of tablets and smartphones, much of the time spent online and offline is not educationally orientated but focused more on the social aspect of being connected. Thus while many of the students do have internet access, the possession of a smartphone (at the expense of a laptop) does little in terms of creating a platform to learn from, but instead serves the purpose of primarily affording them the social connectivity they crave. This observation was particularly noticeable among the younger students from previous intakes at CPUT DMS, however much less so the case with the students at the more senior (S3 and S4) level.

The concept-mapping model that was trialed at the SMA demonstrated many aspects of a CBT model of education that could be tailored to work within a South African environment in order to address the identifiable challenges that exist. Given a blank canvas, and through using the flexibility offered by the system, it is possible to design CBT syllabi that could work in a South African context by factoring in the institution and student constraints from the outset. If properly designed to work within these constraints, the challenges concerning the lack of available resources would not be as great an issue as would be the challenges emanating from the students having a poor academic background (in comparison) at the time of entry to the CPUT DMS.

Before adopting any particular computer software model however, as part of the data gathering process, a review was conducted as to what was being done at the various MET institutions within South Africa. To gather this data, visits were either made to the respective institutions to gain first hand knowledge, or alternatively meetings were held with the Marine Engineering lecturers at the CPUT DMS campus in Cape Town for the purposes of sharing information. It was the intention to gain an oversight of the various practices adopted by each institution, and to review the preferred technology involved with regards to the delivery of the course content on offer.

Once an oversight was obtained of MET practices in South Africa, this information was viewed against the Singaporean concept-mapping model trialed previously at the SMA. It was the intention to ascertain whether or not new or different technologies or learning methods could be adopted from other South African MET institutions, to aid the development of a CBT model that could work in a South African context given the limitations that exist.

4.1.1 Singapore Maritime Academy

The SMA is the only MET institution outside of South Africa that has been reviewed as a part of this study, because of the fact that they were identified as being the benchmark against which a study of this nature in South Africa is compared. As the SMA run a diverse range of courses and research projects, the aspect that is reviewed for the purposes of this study covers the short duration trial that was previously conducted at the SMA with regards to the use of concept mapping software as an educational tool for maritime education.

Having been established as far back as 1957, the SMA offers Diplomas in Marine Engineering among their various other maritime courses that are offered. Recently, the SMA designed and implemented a conversion course for Marine Engineers that is based on skeletal mapping philosophies within the concept-mapping platform CMapTools. This was chosen as the model for use as it is able to involve the learners in constantly developing and updating the course structure (Chatterjea and Nakazawa, 2008). Due to this knowledge mapping and compiling process, learners are able to provide for and discuss updated industry input through co-operative learning methods, with this knowledge being adopted into any future course material that is developed. The idea behind the use of a skeletal subject mapping process was to graphically represent the established subject structure domain, thereby guiding learners towards the pathway approach that the practitioners within the maritime industry would use.

In the case of the SMA, the learners used the blank skeletal maps that were provided to them to develop their own mapping subject pathways, with the aid of the populated file folders that were available for selection. The learners were tasked with reviewing the literature in order to pick up on the important subject topics and concepts that were required to complete the relevant tasks. This approach has benefits in that the student input (through their own experience) is able to reflect their own approach towards how they perceive the available subject literature. The students are further contributing to the greater subject knowledge base that gets built up, through the addition of their own experience-based knowledge that has been acquired. Emanating from this study, certain students were observed to have built on to these pre-formed skeletal maps, through independent subject research that was done in the library or via the internet (Chatterjea & Nakazawa, 2008).

The course required that the students work in groups of two or three, learning from each other as they develop the mapping of their subject matter. Once these collaborative maps are finalised, an important stage in the process began which was the presentation of their understanding to the class for collaborative discussion, debate and validation of their understanding (constructionist principles).

Within the design of the course developed at the SMA, the course material was laid out into two primary sectors that originated from a common thread. One of these sectors represented the factual knowledge track, and the other the procedural track that represented the skills-based aspect of Marine Engineering. One of the stated advantages of adaptive concept mapping is that the students are able to have input regarding the formations of the knowledge structures due to emerging technologies that exist, whilst similarly, the lecturer is introduced to technologies that have arisen in the period since he or she retired from a seagoing career to enter the education field (Chatterjea & Nakazawa, 2008).

The trial conducted at the SMA provided valuable information with respect to the development of a visual mapped course content model, certainly one that could be transferrable to a different environment. Keeping the SMA findings in mind, the MET institutions within South Africa were reviewed to ascertain if anything that was being done locally could be utilised for the formulation of a CBT model, or whether the SMA model presented a better alternative to those currently used for maritime education within South Africa.

4.1.2 Cape Peninsula University of Technology

Marine Engineering tuition started in a classroom environment at the CPUT DMS in 2002. The required syllabus was built up to cover the following disciplines:

(1) S1 and S2 – Engineering Officer of the Watch (12 months duration).

(2) S3 – Second Engineering Officer (6 months duration).

(3) S4 – Chief Engineering Officer (6 months duration).

The subjects offered per semester cover the Mechanical Engineering subjects, as well as the maritime related subjects of Naval Architecture, Legal Knowledge, General Engineering Knowledge, Motor Engineering Knowledge, Steam Engineering Knowledge and Electrical Engineering Knowledge. Prior to 2012, the syllabi were compiled from photocopies of various library sources and from lecturer written notes that covered the requirements of the SAMSA code. In 2012, the syllabi contents were written out by Lambert for each subject in paper format, and given to the students to provide for a singular source of information as opposed to the many document forms that previously existed. These 2012 ring-bound books were amended in 2013 to accommodate the Manila 2010 requirements as per the revised SAMSA code requirements that govern maritime education in South Africa. This was done to accommodate SAMSA's request of attempting to standardise the course content so as to retain uniformity with the various systems from S1 through to S4, and ideally to provide for literature that could be transferrable to similar MET institutions in South Africa (so that the various MET institutions would be reading from similar texts).

Three externally auditable assessments are conducted per subject per semester, which are required to be accessible to SAMSA at any time, and an externally audited (SAMSA) final written examination is compiled and offered at the end of the semester for each of the subject offerings. An additional supplementary examination is also compiled in a similar manner as the final written examination for those students who fell just underneath the subject pass requirements after the initial final examination.

In 2014, as part of this study, the syllabi adopted a digital format that made use of multiple media sources in order to make the subject offering more visual and appealing to the students. The change to incorporate these technologies into the classroom resulted in certain necessary classroom acquisitions such as classroom hardware to display the media, the installation of sound equipment to accompany the visual enhancements, classroom design changes for ergonomic purposes and the obvious shift in the method of tuition to incorporate these technological changes. One of the biggest drivers behind creating a more visual classroom environment was to account for the fact that the students have little exposure to any form of practical engineering components at the CPUT DMS, and have limited opportunities for ship visits during the course of their studies. Many shipping companies are hesitant to allow groups of students onboard their vessels when in port, due to safety concerns (students getting injured) and from commercial aspects in terms of turnaround times being adhered to. Additionally, ship visits would be a fairly time consuming activity to conduct given the limited timeframe with which to offer MET courses, and the ever-growing demands to include new technologies within the traditional syllabi.

CPUT’s Maritime Studies and Survival Centre campus at Granger Bay has been in a state of transition over the past two decades. Originally the building was referred to as the General Botha Maritime College, which was later absorbed into the fold of the Cape Technikon. With changes to the education structures that followed the advent of democracy, these Technikon’s were to evolve into Universities of Technology. As a result of being a University of Technology, DHET have discontinued the existing National Diploma program, and made no future provision for this format on the new National Qualifications Framework (NQF).

In this regard, CPUT has acquired approval from DHET to migrate from the National Diploma programs that have been in place to the degree of Bachelor of Marine Engineering (intended to start in 2018/2019), which is to run for a period of three years. A change of this nature will necessitate shifting the current non-diploma subjects (maritime subjects only) and diploma subjects (maritime and mechanical subjects) possibly to another institution, due to space and lecturer constraints at the CPUT DMS. There have been conflicting viewpoints with regards to the intended progression path that the CPUT DMS wish to follow in the future. The Durban University of Technology (DUT) believes that a MET degree program will not serve the best interests of the seafarer. It is believed that the primary focus of the maritime industry in South Africa should be to produce seafarers that are more in tune with the needs of the seagoing industry, as opposed to producing university graduates.

Feedback from an industry advisory meeting that was held to brief stakeholders of the intended changes[46] indicated that the intended program offering would be well received by the industry in general. Concerns were however raised that the type of student that usually gets admitted through the CPUT feeder system would be unable to afford the costs of the new program in the future, and would be unable to cope academically at the higher level required of a degree program.

The senior SAMSA examiner who was in attendance at the meeting clarified the need for different paths to be taken by the various MET institutions, stating that it was SAMSA's belief that each institution should benefit the region they served in the best possible manner. These differences can be described as follows:

(1) DUT will continue to run the National Diploma program, but will extend the current two-year duration of the study to three years. At the end of the three-year continuous study period, the successful students would obtain a Higher National Diploma (HND), and would then proceed to acquire the practical experience external to the institution. This was felt by DUT to be the best option for their institution, owing to the fact that the secondary school education levels are lower in Durban than in Cape Town, and that they (DUT) personally lack the academic staff within the maritime studies division to enable them to offer maritime degrees.

(2) CPUT will migrate from the current diploma program to a Bachelors degree in Marine Engineering. This degree is not intended to get Engineering Council of South Africa (ECSA) accreditation, which is deemed to be at a higher level academically than will be offered at the CPUT DMS. It is the intention at the

[46] Industry meeting held at CPUT dated 10 April 2014.

CPUT DMS to build on the current established program that has been proven to work, and not deviate dramatically from this in order to facilitate the move academically. The focus of the degree program offering is primarily to produce graduate seafarers and secondly, for the graduates to feed into the various shipping industry support positions that exist. For transferability of the qualification, should the students wish to study elsewhere at a later date, subjects like Mathematics 2 and 3 would be offered as electives.

Like DUT, the program will be spread over three years from its current two year format, to accommodate research projects in the third year and to allow for more time for greater in-depth knowledge of the maritime subject offerings.

(3) The Nelson Mandela Metropolitan University (NMMU) are in the process of curriculating a brand-new degree program with ECSA approval. As a University, NMMU will amend their Mechanical Engineering degree to accommodate the maritime subjects, and maintain close ties with their Mechatronics faculty. In this way, the new MET offering will be conducted at a higher level academically that will be the case at both DUT and CPUT. The Eastern Cape region (where NMMU is situated) has been identified by the South African government as a growth region, and has been prioritised in terms of development, however the secondary school education levels in this region are among the poorest in the country.

NMMU would like their students to (a) obtain ECSA approved qualifications so that they can find employment within the maritime industry, and (b) obtain SAMSA qualifications should they wish to pursue a career at sea after their studies have been completed.

Questions have been raised as to the role a degree program will play in seafarer education in South Africa, especially as only the theoretical component can be offered at both DUT and the CPUT DMS, and limited practical exposure can be afforded at NMMU. The nine-month accredited workshop period and mandatory ancillary courses will need to be offered external to the institutions involved, and undertaken privately by the students in order for them to serve the industry further (at sea) after their study period. Taking all of these factors into account, future Marine Engineering students will only qualify as EOW's approximately six years after entering the MET institutions. This process may have the unintended outcomes that many graduates will prefer to take up a shore-based position as their first preference, as opposed to going on and completing another year of workshops in order to pursue a career at sea.

The degree program is not intended to be able to accommodate seafarers already serving the industry at sea, although these candidates may be eligible for post graduate studies at a later date should they obtain a Chief Engineer's certificate of competency (CoC). The intention is to peg the Bachelor of Marine Engineering degree alongside a Chief Engineers CoC for admission to the Honours programme once it is established. While no distance-learning program currently exists for Marine Engineering education, the possibility of one being implemented through a suitably managed CBT model could aid seagoing educational development for many unable to attend MET institutions due to work commitments. It is therefore the intention that this study also aids this process through the compilation of a CBT model of education that is capable of carrying out this function. In preparation for future distance-learning developments that may possibly come to fruition, and in order to better serve existing seagoing students through affording them a means to study, careful consideration was given to the development of the CBT program from the beginning.

In July 2014, the students that entered the senior class at S4 level were required to attend class equipped with their own laptop computer, onto which the developed CBT software curriculum was loaded for them. Lecture methods included the use of a Power-point presentation covering each chapter onto a projector screen, whilst the CBT program was run on a wall-mounted flat screen television at the front of the class. Students could follow the lectures via the Power-point presentation or CBT monitor (controlled by the lecturer), or alternatively access suitable media and documents via their own laptops running the same CBT program that was displayed in class, as the lectures proceeded. Future use can be made of a smart-board, controlled from the lecturer's laptop computer, to run the CBT program on a larger monitor in an interactive manner. This can be integrated with the lectures to accommodate the preferred visual learning style of the students.

In October 2014, the adoption of a single system from S1 to S4 took place within the Marine Engineering program at CPUT when the core subject textbook was published by Lambert entitled Marine Engineering Theory: Volume 1 – General. This textbook was written from the outset to cover the SAMSA code, and was done primarily to (a) meet the request of SAMSA for Marine Engineering literature that could be used at South African MET institutions at all levels (EOW to Chief Engineer), and (b) to make literature available to both the current MET institutions offering Marine Engineering studies should DUT so desire. The textbook was formulated to work in conjunction with the developed CBT program used for this study, in that text from the book could be complemented with any amount of digital imagery, video clips and animations to further the understanding of the students whilst reading the text. The textbooks was introduced for the General Engineering Knowledge syllabus as a prescribed book for 2015, and adopted at both institutions for use as the core subject textbook.

With the stated intention of adopting suitable e-learning practices at CPUT, it is important to bear in mind what the primary purpose of a CBT model should be, namely to make knowledge meaningful through the visual and audio capabilities that it can offer. Whether text is read off of a computer monitor, or from a book, the words remain just words. The goal of this study implemented at the CPUT DMS is to provide a means of making those words meaningful to students through providing another dimension, and then assessing the effectiveness of this additional dimension in terms of their understanding thereof.

4.1.3 Durban University of Technology

The Durban University of Technology (DUT) in Durban, South Africa, currently offers the same maritime study qualifications as the CPUT DMS in terms of the subjects covered, however the curriculum has been configured differently due to changes made over recent years at each institution.

As part of the initial information gathering process, a meeting was held with the DUT Marine Engineering lecturer where the following questions were asked:

(a) How does the course structure at DUT differ from that of the courses offered at the CPUT DMS?

(b) How do DUT make use of the resources at their disposal in terms of student numbers, timeframes, course delivery methods and assessment criteria?

(c) How do DUT currently make use of technology in the classroom, and what plans are in place (if any) to advance the use of technology in the classroom?

According to Pradyumna Gadaker (DUT Marine Engineering lecturer),[47] in terms of Marine Engineering, DUT offer two primary subjects that cover the core Marine Engineering component as opposed to the CPUT DMS four subject offerings. This is due to the fact that the CPUT DMS previously split the motor component into two subjects (which become motor and steam) and the general component into two subjects (which became general and electrical) shortly after the introduction of the course. As a result of this change, the contact time between the students and the lecturer differs greatly between the two institutions. DUT DMS currently offer 6 hours of contact time a week to cover these subjects, as opposed to CPUT offering 10½ hours of contact time per week. In terms of assessment criteria, six assessments and two assignments are given to the students at DUT, in comparison to eight assessments and sixty smaller scaffold design skeletal map assignments (completed daily) that are given to students at CPUT DMS as detailed in this study.

With regards to the final examination criteria, DUT and CPUT DMS carry out examinations in entirely different formats, as listed below:

DUT	CPUT DMS
Motor: 140 marks, 3 hours	Motor: 96 marks, 3 hours
General: 140 marks 3 hours	General: 100 marks, 3 hours
	Steam: 96 Marks, 3 hours
	Electrical: 70 Marks, 3 hours
Total: 280 marks, 6 hours	Total: 362 marks, 12 hours

According to Pawley (CPUT Maritime Lecturer: Navigation), there used to be a greater degree of commonality between DUT and the CPUT DMS in the past (as the institutions are now known), in that there were common examinations set which were administrated at both campuses simultaneously. It was stated by him that better use was made of collaboration between the two MET institutions in previous years. It was

[47] Information source: P. Gadaker, Marine Engineering Lecturer at DUT from discussions held at CPUT on the 16th October 2014.

agreed between Lambert and Gadaker that while the formats had differed considerably over the years, and that while acknowledgement should be given to the fact that the CPUT DMS was in the process of dropping the diploma and non-diploma programmes in favour of the degree programmes from 2018/2019 onwards, better collaboration between the Marine Engineering lecturers would enhance the subject offering at both institutions, regardless of what format was adopted at each one.

Marine Engineering Tuition Methods

At DUT the classes are currently purely paper-based, with the institution aiming to incorporate the future use of smart-boards in the classroom as teaching and learning tools. DUT plans to develop a greater understanding on the part of the student, and are in the process of looing into using the Blackboard proprietary LMS software as a means of tuition.

A demonstration was given to Gadaker of the software used and the developed CBT material currently in use at the CPUT DMS by Lambert, in order to discuss the development of content material that is better geared towards catering for modern practice found onboard ships. Of interest to Gadaker was the way that the CPUT DMS was able to make use of student input and contributions (in the form of submitted material) that could be used to enhance the course in terms of machinery found onboard ships today. According to Gadaker, one of the challenges he faced as a lecturer at DUT was that he himself had last been to sea in 1993, and was thus more familiar with older technologies. He was eager to incorporate more modern material into the courses offered at DUT. At the request of Gadaker, a 'vanilla'[48] version of the software program was forwarded to himself once it was ready for perusal. This was to assist them in gaining information about the development of e-learning syllabi at DUT, regardless of the eventual platform chosen by the institution for the development of those syllabi.

With DUT prescribing Lambert's textbook for their General Marine Engineering subject in 2015, the two MET institutions moved closer towards gaining commonality in terms of the Marine Engineering subject content. These textbooks were supplied with the

[48] The term refers to the removal of CPUT course dates, and CPUT particular information, and inclusion of the latest information received from student contributions from 2014.

CBT syllabus on Data-DVD format for the four primary subjects as offered at the CPUT DMS, which complement the written textbook material.

Student numbers have traditionally been similar at S1 and S2 levels (Officers of the Watch) and S3 levels (Second Engineering Officer), however at the time of the meeting with DUT, there were only two students at the most senior level (S4: Chief Engineering Officer). In 2015, DUT limited the intake numbers that were admitted to the Marine Engineering stream in order to focus on improving the quality of their academic offering. This reduction in class size resulted in many of the students who were turned away at DUT enrolling at the CPUT DMS to continue (or to embark upon) their maritime study path. This larger than normal admission to the Marine Engineering class at the CPUT DMS, coupled with the inability of the industry to find placement for students at sea (and thus CPUT taking steps to admit them for studies at a management level without them accruing any prior experience), had an impact on the teaching and learning process at CPUT DMS in the first semester of 2015. The consequences of these larger class numbers are detailed within the data analysis section that follows, which reviews the outcomes of each phase of the study undertaken at the CPUT DMS.

4.1.4 Nelson Mandela Metropolitan University

The Nelson Mandela Metropolitan University (NMMU) in Port Elizabeth is gearing up to introduce the degree of Bachelor of Engineering Technology (Marine Engineering) in 2018/2019, at the same time at which CPUT envisages introducing their undergraduate degree program [49] .The path towards curriculating the degree programme was discussed at length, as was the desired synergy between the CPUT DMS and NMMU with regards to the respective degree programs being developed as far as possible.

[49] Meeting held on the 22 September 2014 with H. Theunissen (Senior Lecturer) and O. Franks (Dean of Engineering) in Port Elizabeth regarding the Bachelor of Marine Engineering degree qualification, collaboration, and the use of maritime materials and course methodology.

As part of the initial information gathering process, a meeting was held with the NMMU Mechatronics lecturer Howard Theunissen where the following questions were asked:

(a) How will the course structure that is proposed at the NMMU differ from that of the courses currently offered at the CPUT DMS?

(b) Accepting the fact that the NMMU is not a maritime institution, and that the NMMU propose getting ECSA accreditation for their proposed degree programme, how does the NMMU envisage managing the SAMSA accreditation component of their degree program?

(b) How does the NMMU currently make use of technology in the classroom, and what plans are in place (if any) to advance the use of technology in the classroom?

Not being a maritime institution, one of the primary concerns to NMMU was the unfamiliarity that they have with regards to the practical aspects of Marine Engineering, their understanding of the shipboard procedures involved and their knowledge regarding the use of the various onboard systems required within the field of Marine Engineering. It was requested by NMMU that they take guidance from the CPUT DMS when developing their maritime component, as being a traditional university, they did not yet have the staff in place to curriculate the maritime component. NMMU plan to gain ECSA approval for the program, as they have based their new maritime degree program on an existing mechanical engineering degree program, with the maritime subjects replacing certain specialist subjects within those programs.

A challenge faced within higher education institutions in South Africa has been that of getting the students to purchase textbooks, and this is no different in the case at NMMU. Many students rely solely on the notes handed out to them, and on knowledge gained via the in-class tuition process. This is partly due to (a) the cost of the textbooks, and (b) the notion that the subject is somehow easier for them if they are exposed to a lesser amount of material. One method used by Theunissen to enforce the use of textbooks is to use the textbook examples as a backdrop on a whiteboard projector screen. Onto this backdrop, the calculations are worked through in class, thereby prompting the students to refer constantly to the textbook. As the subjects offered in the mechanical engineering discipline are heavily focused on the use of calculations, NMMU do not use a LMS for conducting their study programs. These practices share certain similarities to those used at the CPUT DMS, where the assignment-focused curriculum repeatedly refers to textbook content for the compilation of the blank scaffold maps.

It was agreed that the factoring in of a practical (or visual) component to shipboard activities should be central to the design of the maritime subject curriculation for both institutions. This would provide for the much-needed visual aspect that is required, and for familiarisation with the various marine components in order to supplement the established mechanical subject offerings currently in place at NMMU. A demonstration was done of the visual CBT model as implemented at the CPUT DMS, showcasing the models ability to aid the lesser-experienced students through the use of the scaffold assignment design configuration. Certain case-based scenarios were discussed, and solutions to these scenarios shown within the CBT environment.

At this collaborative session, the following items were agreed in principle:

(i) It would be beneficial if the degree programs developed at both institutions could utilise a common SAMSA accredited examination standard for the maritime component of the degree between the two universities. This would be set at one of the universities, externally moderated by SAMSA annually, and then written simultaneously at NMMU and at CPUT DMS. The preference by NMMU to adopt the ECSA standard as part of their program would be an addition to the mandatory requirements as detailed by SAMSA, and would require an additional internal assessment on the part of NMMU.

    The motivation for splitting the curriculum in this way is to allow for a degree of transferability between the two institutions should students desire to move between the two. In principle at this stage, the CPUT DMS could possibly accept the NMMU maritime qualification for admission purposes (SAMSA accredited), and NMMU would likely accept CPUT qualifications if the ECSA compliant electives had been completed by the student at CPUT.

(ii) The outline of the program developed should follow the principle (as far as practicable) that the first year covers the EOW academic requirements, the second year covers the Second Engineering officer (2EO) academic requirements and the third year covers the Chief Engineering Officer (CEO) academic requirements. In this way, should the students be unable to complete the degree, they may still be able to withdraw from university studies and slot in at a seagoing level that has been completed. This would require the CBT syllabus be drawn up to accommodate this, and if the syllabi were available to them even though they have left the respective institution, it would allow for students to enroll again at a later date to complete their studies.

4.1.5 The South African Maritime Training Academy

The South African Maritime Training Academy (SAMTRA) is a non-profit organisation funded through donations received from the A.P. Møller Maersk group as a simulator training facility in Simon's Town, South Africa. SAMTRA manage engineering cadets for various organisations, as well as SAMSA's own cadet program entitled the National Cadet Training Program (NCP).

The data gathered was derived from a paper delivered by Gregory Moss (SAMTRA academic instructor) at the 23rd IMLA conference held in Durban, South Africa. According to Moss, SAMTRA wish to introduce distance learning MET education in the future, with the aim of getting SAMSA accreditation for these programs. In terms of maritime education, SAMTRA currently offer various short courses, however, it is believed by them that being able to offer e-learning education at the Engineering Officer of the Watch level will fill a need in the market going forward. According to Moss their desire to pursue this method of education delivery is out of the belief that the current MET education methods offered by institutions of higher learning lack the flexibility associated with modern blended learning education practices.[50]

Currently however, the e-learning process at SAMTRA is still in its research phase, with the primary aim being to fill a market need to cater for students unable to attend classes on a full time basis. Their chosen platform of choice has to be questioned however, in that they plan to make extensive use of tablets and smartphones as a

[50] IMLA conference proceedings, Durban 30th June 2015.

method of curriculum delivery. While this data transmission method may be convenient to some, it would only really be suitable to manage limited data content and imagery as found in many of SAMTRA's current short course offerings. From prior experience, the volume of data required to deliver engineering syllabi in preparation for certificates of competency examinations, requires hardware that is capable of handling large volumes of text and engineering files. This would make the viewing of that content, and the engagement in the learning process problematic on an extremely small smartphone screen.

In the future, it is anticipated that other forms of MET will be adopted in South Africa. Speaking at an industry advisory committee meeting held at the CPUT DMS, SAMSA's chief examiner stated that with the higher education institutions (CPUT and DUT) migrating towards degrees and higher national diploma's, there was a need to cater for students at a lower level. These students could either enroll for study programmes at or the Technical Vocational Education and Training (TVET) colleges, or alternatively embark on self-study programs, as was the case in South Africa previously. These different forms of study would need to be tied together somehow in terms of ensuring the intended outcomes are met at a level required for the relevant STCW qualifications. It was proposed by Lambert that national STCW exams be set annually for each level, which would be SAMSA moderated, to incorporate these different MET education institutional students under one umbrella. While the notion was supported, the details would need debating further before the intended changes set in during the first intake of degree students in 2018/2019. This scenario would enable SAMTRA to embark on their chosen e-learning program in a manner that best suited themselves and their students, and to assess the outcomes of their programs in line with their institutional assessment standards. Thereafter, the students from SAMTRA (and indeed every MET institution) would be required to write an external SAMSA accredited examination to ensure that the student outcomes from the respective institutions meet the same STCW standard.

4.1.6 The Institute for Maritime Technology

The Institute for Maritime Technology (IMT) based in Simon's Town, South Africa performs defense research, conducts short courses, and establishes technology and systems to further the interests of the South African National Defense Force (SANDF).

As part of the initial information gathering process, a meeting was held with the IMT courseware designer where the following questions were asked:

(a) How do IMT make use of the resources at their disposal in terms designing digital learning programs for naval officers?

(b) What forms of collaboration and information sharing is possible between the IMT and the CPUT DMS with regards to designing CBT digital learning systems for the CPUT DMS?

According to IMT head designer Alfonso Hendricks[51], IMT produce a range of software applications across various platforms that serve as an aid to the respective SANDF lecturers with regards to the running of short courses. The software applications are developed on a laptop computer primarily using the Studio 13 software suite Keynote and Tumult Hype, in order to develop electronic books and animated learning material. These developed products are saved as HTML files, which can then be uploaded to an iPad using the iBooks platform, or to any standard laptop with a web browser.

The web browser is configured to use the laptops internal built in browser so as to save on the data transmission requirements of running a graphics system, and to factor in the issue of limited web connectivity in certain areas where the courses will be conducted (i.e. the running of short courses at sea). As part of these courses, checklists are required to be completed (in tick-box format) by the students, to demonstrate their understanding of the course content. These checklists are retained on the devices, and then later emailed as an attachment to Hendricks for perusal at a later stage (i.e. when a connection becomes available again).

As a method of conducting e-learning courses, the method by which IMT have adopted to manage training when internet connectivity is unavailable is capable of meeting the requirements of the CPUT DMS. However, one vital factor that needs mentioning, is that the defense force is not as restricted as the educational institutions are with regards to funding for systems and software development. If a similar system were to be used by the CPUT DMS, the software acquisition would become a

[51] Meeting held 16 September 2014 on the topic of collaborative efforts and mutual learning regarding blended learning systems

university expense thereafter the material developed could be loading onto the various forms of mobile devices at no cost to the student in a HTML format.

Despite being competent as a tool for conducting short courses, the produced software has other certain negative aspects when placed in a CPUT DMS context for the running of an entire Marine Engineering curriculum. The primary concern is that there could be a danger that the student becomes an operator of a produced HTML file format course, as opposed to be actively engaged and participative in the e-learning process. CBT/LMS systems should promote input and dialogue on the part of the student to challenge the individual involved during the learning process, with information sharing flowing in both directions, as opposed to completing pre-set checklists.

Although the course materials developed by IMT and the direction that the CPUT DMS envisage taking differ in their design and application, the animation generating capability of the studio 13 suite could benefit the CPUT DMS in terms of the design of interactive software. HTML file generation would slot in well within a concept mapping application, as links could be simply configured to open within a web browser, however one would have to query why this would be necessary when the open-source CMapTools program could be configured to run internally, and would allow the students to more easily customise their learning experience. Additionally, the transfer of files to the iPad/iBooks platform is not something that would be considered within the course of this study, as a result of IHMC not producing CMapTools software for tablet use at the time of development.

As a result of this period of the research, many positives were noted with regards to the compilation of the CBT model favoured by the CPUT DMS, both in terms of material and animated media. Both of the software programs demonstrated have merits for developing naval course material, however it was evident that caution need be exercised from a university perspective in that the sheer volume of information required would make this form of software development a lengthy and laborious task for a single university lecturer. A second concern is that many animated applications can simply become too busy, and ultimately distract the end-user away from the basic principles of Marine Engineering theoretical instruction in the process.

4.2 South African Institute of Marine Engineers and Naval Architects feedback

Shortly after the CMapTools syllabi had been populated with the necessary written material and visual media, it was deemed prudent to engage the industry role players in order to gain as much feedback as was possible. It was the intention that once populated, the educational system devised could evolve in tune with feedback or innovative ideas received from outside of the MET institutions, and to listen to any concerns that they had, if any. The South African Institute of Marine Engineers and Naval Architects (SAIMENA) was approached to see if their members could be addressed at some stage. Following a swift response from them, a keynote address was delivered at the SAIMENA annual luncheon that was attended by senior SAMA personal, as well as other industry role-players.

After a demonstration of the system that had been developed was given, the concerns raised by the members primarily centered around the poor academic outcomes that were achieved at MET institutions when it comes to the younger students. The main reasons behind these poor outcomes were stated as being (a) a result of the limited number of available berths that are designated for cadets on South Africa ships, and (b) the business nature of the MET institutions in terms of meeting their student throughput rate targets, at the perceived expense of producing better quality. In summary, the following topics were fielded which were discussed as follows:

<u>Challenge # 1: Addressing the lack of seagoing experience at the operations level</u>

It was noted by Lambert that only 9% of the S1 intake for the 2014 year (Officer of the Watch candidates) had ever been to sea before, and that this group achieved an examination pass rate for the primary subject (General Engineering Knowledge) of only 16%.

<u>Feedback</u>

Those attending were positive that a move to an e-learning syllabus would go a long way towards better engaging the younger generation of students, while providing the much needed visual component to the studies that they lacked due to the limitations that exist by not being able to place the students on ships.

There was also general consensus that the limited amount of resources available to implement this CBT model at a more junior level would present challenges in terms of funding, should the e-learning syllabi be rolled out to the operations level after the study was completed. However, given the price of textbooks, (which surprised many of the members), there was agreement that a laptop could be purchased for the same price as one of the two most expensive textbooks in the range (R 3,600). The implementation of this system at these levels would require either (a) CPUT funding to acquire the resources to be based at the CPUT DMS, (b) the CPUT DMS to supply laptops as part of the course material or (c) the student supplies their own laptop computer as a course pre-requisite – as has been done at the senior levels. These concerns will be addressed further once the outcomes of this study at the senior levels have been analysed.

<u>Challenge # 2: Future migration towards the degree program (Bachelor of Marine Engineering)</u>

As mentioned previously, from 2018/2019 onwards it is the intention at CPUT to start offering two maritime degrees at undergraduate level, and to start phasing out the current National Diploma program that is in place. These degrees are to be titled: (a) Bachelor of Nautical Studies, and (b) Bachelor of Marine Engineering. Once started, the current programs will be slowly phased out (to accommodate those students still at sea), where after the program may be passed on to the Further Education and Training Colleges (FET's) for seafarer education at the non-degree level.

The concerns of the industry regarding the degree program can be listed as follows:

(1) In recent years, there has only been one SAMSA accredited institution in South Africa that can offer workshop training to Marine Engineering cadets, which is situated in Kimberley, 1,000 kilometers from Cape Town. In 2015, (after the SAIMENA address), further institutions in Cape Town have gained accreditation by SAMSA for workshop training. Workshop training (which is a seagoing requirement) will however not be included in the degree program in order to reduce the cost of the degree program, which is a key concern with student representative bodies in South Africa.

Should students wish to complete the necessary workshop training, this would be at their own expense after the duration of their theoretical studies at the CPUT DMS, either straight afterwards, or after a period of sea service. This point was raised as a concern by some of the members, as it was viewed that the degree program is not a wholesome programme offering that included practical components, but only one that addresses the academic component of Marine Engineering.

(2) In a similar manner to the first concern raised, the many ancillary courses required to obtain certificate of competencies will also not be included in the degree program. These two omissions would mean that once a three year degree has been obtained, a further 18 months of courses would be required (at the students own expense) before they could serve the industry at sea. Those wishing not to complete the practical component can still work within the maritime industry, however not in a seagoing capacity.

(3) As the degree offering is purely classroom based, the program largely excludes those seafarers currently serving the industry at sea from obtaining an undergraduate degree. This is because those who are working within the industry would likely be unable to afford the time off in order to spend three years consecutively in a classroom. It is therefore a belief that the degree programs will in future only become a reality for school leavers, and would not aid the established career seafarers to further their maritime qualifications.

<u>Feedback</u>

The last concern could be addressed if the degree program retained a certain amount of flexibility and had the ability to embrace part-time students who could still serve at sea and attend classes on their time on leave. A point was raised by Lambert, that he had been able to study for and obtain an MBA in Finance over a three-year period whilst serving the industry at sea (via e-mail submissions as required), yet currently it is not possible to study Marine Engineering in South Africa whilst working at sea. This point did highlight the need for distance learning in the maritime industry to become a reality.

The members (once they became acquainted with the CBT model developed) believed that the limited e-mail data transmission requirements of the system made seagoing study a possibility. Distance learning in MET circles is being debated at present, and if an agreement is reached in the future, it remains a possibility for the more established students to join the undergraduate degree program should they wish to do so. As many of the members had come from a seagoing background, the ability of the CBT model to accommodate this limitation was appreciated.

It was further agreed that greater collaboration was necessary between MET institutions so as to strive for one standard (EOW to Chief Engineer), and for the development of common syllabi between the currently fragmented groups. This would benefit those students who may wish to move between MET institutions in order to continue their studies elsewhere if needed.

4.3 Summary of findings with respect to MET in South Africa

After reviewing the respective systems that were in use at the various MET institutions that were chosen for this study, and looking at the developments that took place during the CMapTools trial at the SMA, it was confirmed that the concept-mapping software CMapTools would represent the best system for use at the CPUT DMS. Whilst circumstances within the two countries differ greatly (Singapore and South Africa), the concept-mapping model demonstrated a flexibility that cannot be found with the other systems in terms of portability (no internet required), cost and IT support level requirements.

While the media content developed by IMT was impressive and found to be useful for MET purposes, the costs involved and lecturer time constraints at the CPUT DMS meant that this form of CBT development was not a viable option. NMMU were found to have established practices in place that worked for them (calculation intensive), however due to not having an established MET program as yet, little could be transferred for use at the CPUT DMS. Similarly, while the remaining South African MET institutions all proposed greater use be made of CBT/LMS systems in the future, none were found to be at an advanced stage in this process, and as such, did not present a working model that could be implemented for use at the CPUT DMS.

Summarising the feedback obtained regarding MET at the respective institutions, and listening to the input from the SAIMENA members, it became clear that there was widespread support for the adoption of a CBT model of education similar to that found at the SMA. The adopted model would however need to fit the profile of both the students and CPUT (Muirhead, 2002), which meant that the model would require certain design differences to that which was implemented at the SMA.

Due to the lack of IT hardware at the CPUT DMS, it became necessary to differentiate somewhat from the SMA model, in that each student would be required to bring their own laptop to class. Each student had the software loaded (CMapTools) and populated with the marine Engineering curricula that had been developed. In this way, (a) internet-access was not a requirement, (b) data transmission limits in terms of downloads was avoided and (c) those students who were required to break from their studies for a few weeks to help their companies out at sea could continue via limited email transfers of attached files. A further aspect of this structure has meant that a reduction in the CPUT DMS hardware requirements affords less risk to the CPUT DMS, as the associated risk is transferred to the individual students.

As a result of this research, the population and development of Marine Engineering syllabi for use at the CPUT DMS, using the CMapTools open-source software program began. The development of the curricula that is detailed in chapter six, began in February 2014 in order to be ready for implementation in July 2014. Before detailing the CBT design process, the method used with regards to the research methods used, the data collection, the CBT development and the data analysis is outlined in the chapter that follows.

CHAPTER 5

RESEARCH METHOD

Introduction

This chapter explains the research objective, describes the research paradigm adopted and explains the research methods that have been used in order to suitably answer the research question as posed in the introduction. The research undertaken has been done through a process of action research within a single case study environment, as found within the CPUT DMS Marine Engineering faculty. The ability to obtain in-depth research findings through the use of this form of single case-study research is detailed alongside the addressing of certain negative connotations that may assist with conducting single case study action research, as a research method.

The role of the researcher and implementer is described within this process, with a view towards stating the primary benefits associated with being native[52] within the research process, as well as to gain an understanding of the main challenges faced through the use of being an insider researcher[53].

The research participants, the data collection process, the research instrument that was developed and the research measurement criteria are explained at the conclusion of the chapter, before the research environment and data collection tool are described in greater detail.

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[52] The term 'native' describes the process of insider research, where the researcher conducts research within their own organisation (Brannick & Coghlan, 2007).

[53] The term 'inside researcher' refers to research conducted by members of organisational systems and communities in and on their own organisations, as opposed to research conducted by a researcher temporarily joining the organisation for the purposes and duration of the research (Adler & Adler, 1987).

5.1 The research question

The formulation of the research question derived at for this study has taken guidance from the thoughts of Novak and Cañas as described in the introduction, as Novak's belief aligns itself well with the challenges facing MET is South Africa. To reiterate, Novak believed that the lack of available resources in developing countries (that more affluent countries have regarded as being essential) could largely be obviated by the use of emerging technologies[54] (Novak & Cañas, 2004).

The research question to be tested by this study is as follows:

> *Could technology be used to counter a lack of available resources, in order to improve the academic outcomes of Marine Engineering students in South Africa?*

In order to compensate for the lack or resources on the part of the CPUT DMS, and thus to answer the research question, the following steps have been taken in order to carry out this research:

(1) The classroom computer infrastructure has been developed to facilitate e-learning in a manner that aims to compensate for the practical shipping-related components that are omitted from the course.

(2) The CBT model has been constructed, and altered at each phase of the study in accordance with constructionist design elements of Seymour Papert. This was done to ensure participation on the part of the students, and to ensure that their workings could be externalised among their peers.

(3) Selected learning methods have been chosen within the design, which have been based on theories of Lev Vygotsky and Albert Bandura. The CBL

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[54] Refer Chapter 2.1 - The term 'emerging technologies' as used by Novak is used within this study to represent technical evolution within the context of the environment in which the study is conducted. Emerging technologies are technologies that can be classified as being capable of changing the status quo, and can include both new and older technologies that are still relatively undeveloped in potential. Technological evolution can represent the application of existing technologies to a new domain of application, where existing technological know-how can be implemented within a new application domain, to allow it to evolve in new directions (Adner & Levinthal, 2002).

component was configured to provide for additional scaffolding elements that could support and explain the written text, and GBL was used to facilitate dialogue among the students when compiling the assignment maps, and conducting the case studies.

The testing of the research sub-questions, and ultimately the research question, has been done through an interpretivist paradigm, using a data triangulation method to better clarify the research findings.

5.2 The research paradigm

An interpretivist paradigm (constructivist) has been chosen to form and guide this research as this approach is deemed to be able to fulfill the research objectives. Within this paradigm, however, both qualitative and quantitative methods have been used to collect and analyse the data obtained. Although this study is heavily reliant on the quantitative analysis undertaken, within the environment that the study takes place, and as a result of the nature of the study, a 'softer' approach has been adopted as opposed to 'harder' positivist norms due to the action research process adopted. As this study is conducted within a single case study environment, with the aims being to 'problem solve' the identifiable challenges that exist within that context, the view taken is similar to that of Guba and Lincoln (1994) in that generalisations, although perhaps statistically significant, have no applicability to any particular case. This view is in line with the interpretivist paradigm, as applicable to a single case study environment. The quantifiable data analysis should therefore assume priority within this study of playing an important role in the representation of reality (participant behavioral observation through assessments) and problem solving within the context of the study.

Constructivist paradigms reflect ontological relativism as opposed to ontological realism, often assuming conflicting social realities, requiring an epistemological position that sees knowledge being created through the interaction between the investigator and the respondents (Guba and Lincoln, 1994). This interaction, conducted through an action research process, has been selected as a test-retest method of problem solving within the particular case. Quantifiable data has been analysed within this study, and used along with certain indicators (i.e. grading according to the Blooms taxonomy scale) in order to obtain a perspective of the depth of student understanding. This understanding is to be taken in the context of the particular case (interpretive), for assessing changes that occur in these levels of student understanding (if any) over the duration of the study, within the singular environment.

5.3 The research method

5.3.1 Action research

Action research is often used as a research method to deal with concrete problems in an immediate situation (Cohen, Manion and Morrison, 2007). The primary strength of action research as a research method lies in its ability to generate solutions to the practical problems that exist within the study environment (Meyer 2000). Action research can be viewed as "an experiential approach to learning" that changes according to the needs, in order that the methods, data and interpretation can be continually refined according to the understanding derived from the method. The research method is often described as using a series of 'spiral steps', each of which includes a planning element, the action components and finally the fact-finding about the results of the action (Lewin, 1946)[55].

Action research has a dual aim as a research method, benefitting both the researcher through the generating and testing of theory, and the respondent through developing tools and processes for the solving of challenges. Through seeing the action research process of inquiry as a means of using reality, as opposed to representing reality (Reason, 2006), the relationships between claims and reality become causal rather than representational.

[55] Kurt Lewin (1890-1947) was an influential German-American psychologist first coined the term 'action research', became a pioneer in the study of group dynamics and organisational development.

PHILOSOPHICAL FOUNDATIONS	POSITIVISM	CRITICAL REALISM & ACTION RESEARCH
Ontology	Objectivist	Objectivist
Epistemology	Objectivist	Subjectivist
Theory	Generalisable	Particular
Reflexivity	Methodological	Epistemic
Role of the Researcher	Distanced from Data	Close to Data
Data Relationship	Examines Theory to Contribute to Practice	Examines Practice to Contribute to Theory

Figure 12: Table – Research Paradigm (Adapted from Coghlan and Brannick, 2005)

Through a process of reflexive awareness, action researchers can articulate tacit knowledge within an organisational system and reframe it as theoretical knowledge. An action research process follows a subjectivist epistemology, but retains an objectivist ontology in order to expose interests and enable freedoms through self-reflexivity (Coghlan & Brannick, 2005). The action research process within a single case study environment (close to the data) is one of epistemic reflexivity, denoting reflection upon the social conditions under which the disciplinary knowledge comes about and gains credence (Bourdieu & Wacquant, 1992).

It can be argued that action research is harder to do than conventional forms of research (Baskerville, 1999; Dick, 2010), as responsibilities lie with the researcher for both the research element and the change that occurs within the processes. As most research methods rely on control, standardisation, objectivity and procedural correctness, any form of flexibility or procedural changes that are made can increase the chances that the results obtained may have occurred by chance. This point differs from action research where the very notion of standardisation defeats the purpose, as the primary virtue of action research as a research method is responsiveness (Dick, 2010).

While many view the strengths of action research as more important and significant than the weaknesses (McKay & Marshall, 2001) it is important that the challenges with regards to the choice of action research as a research method be noted, to ensure that they are adequately addressed in a study of this nature. In terms of being an acceptable research method, action research often does not strike an accord with many academics, as the methodological perspectives and principles differ from their own experiences. Other concerns regarding the action research method include a perceived lack of impartiality and bias on the part of the researcher, that the research conducted will lack scientific rigour and validity, and that it is sometimes problematic when identifying causal connections when interventions have been made. Action research as a method differs to positivist forms of research in that as opposed to examining theory to contribute to practice, it is used to examine practice to contribute to theory.

Morrison and Lilford (2001) believe that for an action research approach to be categorised as being ideal, it is required to fulfill the five tenets described below. These five tenets are described, alongside reasoning as to why action research can be considered a scientific form of research.

(1) The flexible planning tenet: The direction and content take shape as the research progresses, with both of these being under constant review.

(2) The iterative cycle tenet: The research activity should cycle to include (a) consideration of the problem to be researched, (b) a proposal of the action to take to solve the problem, (c) implementing that action plan, (d) learning lessons from the results of that plan, (e) reconsideration of the problem with respect to the lessons learned, and then reverting back to point (b) to begin the cycle again as often as is required.

- Scientists have traditionally defined a detailed problem in advance (starting point), and then strived towards deriving an answer to the problem. As research aims to arriving at a point with a clear formulation of a problem that requires solving, the position of where this point is does not need to be specified from the outset for the method to be called scientific.

(3) The simultaneous improvement tenet: The research problem should be aimed at correcting the problem whilst in the process of conducting the research.

- Firstly, scientists have traditionally had no principled objection to the changing of concrete situations through the course of conducting research, and;
- Secondly, within social research, there is a claim by some that no objective facts can be discovered (which assumes everything about the social world is subjective), and that those who conduct the research inappropriately assume there are objective facts (a point which undermines itself, because if true, the notion that the researcher acts in a particular way becomes an objective fact in itself).

Both of these points above indicate that the simultaneous improvement tenet is actually irrelevant with regards to whether an enquiry can be considered to be scientific.

(4) The subjective meaning tenet: The subjective meanings and situational definitions within the problem must be allowed to determine the direction, content and success measures of the research.

(5) The unique context tenet: An ideal action research project must factor in the complex, ever-changing and unique nature of the social context within the study environment.

- Physical sciences embrace realism and not idealism, objectivism and not subjectivism, holism and not particularism, and monism as opposed to pluralism. However, within action research, provided that the philosophical assumption within a study is supported by reasoned argument, the three basic requirements for scientific status, explanatoriness, comprehensiveness and falsifiability are all that is required for a scientific enquiry.

This study is more closely aligned to the iterative cycle tenet, through the way in which the study has evolved at each phase to implement the selected learning methods used. However, recognition was given throughout to the unique context in which the study takes place, in order that the development of the model could be aligned with needs and abilities of the students.

Systemic action research (SAR) is a form of action research that focuses on developing a systematic understanding of how change happens, so that processes can be designed to engage participants and determine causality between method and outcomes. Because action research is a process that is designed to stimulate freedom of thought and sustainable change, it is important that action research practitioners have an understanding of how change happens (Burns, 2014).

Educational action research has emerged as one of the 'streams' of action research (O'Brian, 1998), which was founded after John Dewey[56] who held the belief that it is important for professional educators to become involved with the solving of community problems. Within educational action research there are two primary types, namely practical action research (local scale, addressing specific issues) and participatory action research (larger scale, social and community problem solving). For this study, the type of action research used can be defined as practical action research, which defines the method as addressing 'local' problems through the implementation of specific activities.

The 'local' challenges identified at the beginning of this study (through the initial surveys conducted) were primarily twofold, namely (a) the relatively poor English language skills due to the diversity of the student body, and (b) the low levels of seagoing experience (on average) among the students. The activities created to address these shortcomings included the development of CBL activities (experience), using GBL (language) as methods to promote positive interaction between the research participants.

The concerns with action research as a research method, conducted within a single case study environment, have been addressed in the sections that follow within this chapter, however it does raise an important question: What determines quality in action research? Reason (2006) believes that the quality lies internally on the researcher's choices and on the consequences of those choices, and externally with the articulation and transparency of the research when exposed to the wider public. It

[56] John Dewey (1859-1952) was an American philosopher, psychologist and educational reformer, who is regarded as being influential in the fields of educational and social reform.

is also important that the judgements that are derived from the method are connected to current literature, and to similar studies that have been conducted.

5.3.2 Case study research

This research has taken the form of a singular case study that has allowed the researcher to use action research to investigate phenomena in a greater depth than would have been the case with a multiple-case design. This process was able to offer a rich insight into the noted understandings. Case study research has the ability to achieve numerous research aims, primarily to (a) describe phenomena, (b) to develop theory, and (c) to test theory (Darke, Shanks & Broadbent, 1998).

The academic research conducted for this study has been done through the researcher being native to the environment, which allowed for the drawing on insight gained through lived experiences (Brannick & Coghlan, 2007). There are advantages to conducting single case study research in this manner as an insider researcher, namely (a) the researcher has an understanding of the culture being studied, (b) the flow of interaction between researcher and the sample population remains unaltered, and (c) an established intimacy exists, which promotes the telling and judging of greater truth (Unluer, 2012). As the research setting in this case was the researchers work area, all of the data collected was done as an insider participant observer (being a member of the group as well as the researcher). Further advantages associated with conducting case study research in this manner, included the fact that access to past student records could easily be obtained to facilitate the research process, which would not necessarily be the case for an outside researcher.

This in-depth case study research, whilst allowing for an intimate understanding of the research environment, required consideration of the disadvantages associated with conducting research via a single case, if the research findings are to be as accurate as possible. One of the primary concerns is that the greater familiarity that exists could lead to a loss of objectivity. Additionally, due to the researchers prior knowledge, an element of bias may result in incorrect assumptions being unconsciously made (Unluer, 2012). It was important that these issues be addressed through triangulation of the research findings as much as possible, and through ensuring transparency with regards to the data collection and analysis process through the moderation and professional peer-review processes used.

Case study research has to ensure that the research findings are not lacking scientific rigour and reliability, and that the generalisability of the research findings be addressed and documented. A way to enhance the generalisability of the findings is to include two or more participant groups within the single case study. Should replication of the research results be found between these participant groups, the research outcomes can be viewed with greater confidence in terms of consistency (Noor, 2008). The interpretivist paradigm allowed for each of the three student groups within this study to be viewed within their own context, thereby affording for a certain degree of comparison between the noted outcomes of each of the student intakes.

This single case study was longitudinal in nature as the study was conducted over a period of eighteen months (three successive six-month semesters), and included repetition with regards to the data collection process. The participants comprised three different groups of students during each successive semester, which aided in enhancing the generalisability of the research findings. Triangulation methods were used with the data collection and analysis in order to ensure that transparency and validity of the research findings could be maintained.

5.4 The role of the researcher and implementer

It is a requirement for lecturers who conduct action research within education to get actively involved in the teaching and learning process in order to achieve the greatest impact. Another point to consider is that at the CPUT DMS (owing to the small size of the South African maritime sector), the researcher that is involved in this study is the only lecturer with the maritime qualifications to be approved by SAMSA to give classes at the management level. As a result, this particular research could not be conducted as a peripheral person.

The role adopted in order to conduct this research has largely been shaped by the nature of the research itself (i.e. the research being conducted hands-on in a classroom environment). The CBT model used to collect the data was therefore developed before being implemented at the beginning of each semester, and the outcomes from using the system later analysed in terms of it's effectiveness as an educational tool in order to successively improve the CBT model.

Being both the researcher and the implementer however raises questions as to the legitimacy of a process whereby the researcher essentially evaluates their own work. However, it must be taken into account that the goal if action research is often interpretive as opposed to being exploratory, and is carried out in order to seek meaning and understanding (Feldman & Minstrell, 2000). Another often cited negative aspect of action research is that as a methodology, it often lacks rigor[57] (Baskerville & Wood-Harper, 1996).

Lawrence Stenhouse (1975) defines research as 'a systematic critical enquiry made public', and in order to ensure that the action research methods used for this study be regarded as legitimate and rigorous, the process must ensure that it be regarded as one that is open to critical review. To ensure legitimacy and to reduce researcher bias, various triangulation methods (such as external moderation processes, qualitative assessments and a 'professional peer' review process) have been used to confirm or falsify any causal links that may exist. These triangulation data collection methods are described in the sections that follow.

5.4.1 Research bias

The nature of action research poses certain challenges with regards to ensuring that the study outcomes are reliable, objective and valid. In terms of the quantitative data analysis, so as to ensure the measurable student outcomes from each stage of the study became a true reflection of the learning method in use (despite the limitations regarding different student groups), the following triangulation methods have been used to reduce researcher bias:

(1) 2 Stage moderation process: The first consideration was to ensure that the assessment criteria used (the quantitative measuring instrument) was of a similar standard throughout each phase of the study for the respective groups. To ensure that different papers maintained a similar standard, once set, the papers were sent for internal moderation at CPUT, and afterwards for external

[57] Rigorous action research is concerned with producing valid scientific explanations, and the use of multiple methods to produce valid research constructs.

moderation at SAMSA. This was done to obtain two objective crosschecks for quality assurance purposes.

(2) Peer review of standard: After all of the papers were written by the students, and after all three phases of the study were completed, the papers were distributed via email to professional peers within the industry in South Africa (both Class 1 CoC Chief Engineers, and SAMSA examiners) for a comparative evaluation. The dates were removed from each of the papers, and these participants were asked to grade the papers in order from what they perceived to be the easiest through to those that they perceived to be the most difficult.

As the size of the South African maritime industry is small, a total of twelve surveys were distributed, and a total of twelve surveys were received. The results from this survey were used to ensure that the observable student outcomes at each stage could be placed in perspective alongside each other, and to test if any statistical significance existed in terms of the observable outcomes from each phase of the study.

5.5 Research participants and research data

<u>Study participants</u>

The population who partook in this study comprised of the Marine Engineering students at the management level at CPUT from January 2013 to December 2015, over four successive six-month semesters.

The first group of students (January to June 2013) did not participate in terms of observable student outcomes, but rather provided data that was used to decide upon and develop the CmapTools software that was to be used as the measuring instrument for this study. The initial student analysis surveys were conducted at both the entry level (S1) and at Second Engineering Officer levels (S3). Participation in this survey was purely voluntary, with consent being given by those participating students to use the data for the purposes of this study, after which the data was disposed of as per the WMU ethics committee requirements. A total of 74 initial surveys were conducted in January 2014, which included 56 surveys at the Officer of the Watch level (S1) and 18 at Second Engineering Officer level (S3).

The students from the three successive semesters that followed had their academic outcomes evaluated after using the CMapTools CBT syllabi from a quantitative perspective (marks) and their viewpoints about using the particular CBT model noted from a qualitative perspective (surveys). Quantitative data was assessed at each phase of the study in the following manner:

(1) Phase 1: During this phase of the study a sum total of 235 assessments were graded (computer based syllabi), and the results compared with the previous group of S4 students (paper based syllabi) where 249 assessments were graded.

(2) Phase 2: During this phase of the study a sum total of 490 assessments were graded (combined computer & paper based syllabi), and the results compared with the previous group of S3 students (paper based syllabi) where 239 assessments were graded.

(3) Phase 3: During this phase of the study a sum total of 300 assessments were graded (computer based use of selected learning methods), and the results compared with the group of S4 students from the first phase of the study (computer based syllabi) where 235 assessments were graded.

5.5.1 Action research process

Consent was given in writing for the data that was collected at each phase of the study (for both quantitative and qualitative analysis) to be used. During this study, all of the data collected and used was kept confidential, there was no need to disclose any names or personal details for the purposes of this study, and no names or student numbers were made public in any manner.

<u>Student information gathering</u>

In order to get an insight primarily as to (a) the resources available to the students, (b) the English language capabilities of the students and (c) student industry experience levels, an initial student information survey (survey 1 in the appendix) was conducted in January 2014. A total number of 74 surveys were completed by the students (within the operations and management level classes) and this information was used to aid in the design and population of the CBT syllabi that were used.

Phase 1: CMapTools use only

In June 2104 when the first phase of the study began at the management level (S4 students), 28 student information surveys (survey 1 in the appendix) were distributed among the group, of which 18 were received. These 18 surveys were used to compile experience profiles for the participating students, where it was intended over the course of the study to test for any statistically significant changes that occurred from group to group. Quantitative data was garnered throughout the six-month period that followed, from the two written assessments and examinations done by all the 28 students for each of the four subjects. And finally, this phase concluded with the distribution of survey number 2 (CBT qualitative survey) to illicit information as to the effectiveness of the developed CBT tool in comparison the paper based syllabi that were previously in use. A sum total of 12 of these follow-up surveys were received from the students, out of the 28 that were distributed.

Phase 2: CMapTools used in conjunction with written literature

In January 2105 when the second phase of the study began at the management level (S3 students), 47 student information surveys (survey 1 in the appendix) were distributed among the group, of which 38 were received. These 38 surveys were again used to compile experience profiles for the participating students, where it was intended over the course of the study to test for any statistically significant changes that occurred between successive groups at the same level. Quantitative data was garnered throughout the six-month period that followed, from the two written assessments and examinations done by all of the students that remained with the program for each of the four subjects. This phase concluded with the distribution of follow-up survey number 3 (learning preference survey) to illicit information as to student preferences at the junior management level. A sum total of 29 surveys were received from the students, out of the 35 that were distributed.

Phase 3: The introduction of the selected learning theories

In June 2105 when the third phase of the study began at the management level (the second group of S4 students), 31 student information surveys (survey 1 in the appendix) were distributed among the group, of which 19 were received. These 19 surveys were used to compile experience profiles for the participating students, where it was intended over the course of the study to test for any statistically significant changes that occurred from the first phase of the study, and to subsequent paper-based syllabi outcomes. Quantitative data was garnered throughout the six-month period that followed, from the two written assessments and examinations done by all the 31 students for each of the four subjects. And finally, this phase concluded with the distribution of follow-up survey number 4 (learning methods survey) to illicit information as to the effectiveness of the selected learning methods that were used during the course of the semester. A sum total of 13 surveys were received from the students, out of the 22 that were distributed.

Survey information

Of primary interest with regards to collecting student information at each phase, was the allocated experience rating for the student, and the data points that were loaded against that particular rating profile. These profiles were grouped together to compile the data sets in order to conduct an analysis of the assessment outcomes.

With regards to the quantitative data collection method used (assessment results), each student assessment or examination counted as one data point. Each student wrote two assessments during the course of the semester and one examination at the end of the semester per subject that they were enrolled for. The assessments were all an hour and a half in duration, and the examinations were three hours in duration.

The data was uploaded to CPUT’s marks administration system (MAS), to an open-source statistical analysis software package called Software Open for All (SOFA) and managed for tabling and backup purposes on Microsoft Excel spreadsheets. Once tabled, these figures were interrogated to determine whether any form of statistical significance existed by (a) looking at trends of outcomes in terms of marks (factoring experience levels and the perceived degree of difficulty), and (b) using three chosen growth models to determine whether or not any sections of the student groups fared better than any of the others.

5.5.2 Data collection time frame

The time frame for each phase of the study followed a similar repeated pattern throughout, in line with the semester programmes offered at the CPUT DMS. Students enroll for a period of just over five months a time, with a mid semester break of a week in the middle of the study period, with the last three weeks being allocated for examination scheduling. The classroom tuition time was allocated twelve weeks of actual contact time in total, with the workload split into twelve equally sized modules in order to work through each syllabus at a steady pace. The first assessment took place in week four of the semester, the second written assessment in week eight of the semester, and the final written examinations taking place after a week allocated for examination preparation (once the classroom contact time had ended).

In the final quarter of the third phase of the study (October and November 2015), nationwide disruptions of Universities and Universities of Technology due to protests over student fees[58] resulted in the semester being shortened by a week, and a postponement of the final written examinations. At the CPUT maritime campus (which is a satellite campus), the disruptions were not as intense as was the case at the larger campuses, and as a result the maritime students were able to write the examinations at an undisclosed venue on the campus. A few students missed the final examinations due to them needing to vacate the residences, and returned to write supplementary examinations in January the following year (2016). These data points were not counted into this study, as the numbers were very limited and a different externally audited examination was provided for these supplementary exams.

Factoring in the contact time lost (one week), and the two-week deferment of the examinations, the data collected is considered to be what it would be without the disruptions. However, the effect in terms of student outcomes from the student trauma experienced as a result of the violent protest action may have had an impact on the final written examination results. This cannot be confirmed, and is regarded to fall outside of the scope of this study.

5.6 The research instrument

The research instruments used within the interpretive paradigm included (a) surveys conducted at each phase of the study, for both quantitative and qualitative data collection purposes, and (b) quantitative data tables of assessment marks from CPUT

[58] #FeesMustFall is a student led protest movement that began in October 2015 in a response to an increase in fees at South African Universities.

marks administration system (MAS) and from Excel spreadsheets of marks kept throughout the study.

Surveys were distributed to each of the class groups for voluntary participation. Those students that responded to the survey had their data captured against their student numbers in order to determine (among other items), an experience rating for each participating individual within the population sample. Once assessment results were forthcoming, these were captured against each participating individual.

Additionally, every student who wrote assessments had their results captured on a nominal scale to look at group trends between the respective phases of the study. This was done to look at overall results, separate from that of the population sample. Consistency with regards to the survey procedure was maintained throughout with the same student information survey (survey 1) being distributed each semester over the two-year period. This was to ensure validity with the sampled data, and that the data received was consistent throughout.

<u>Quantitative data collection</u>

(1) Survey 1: Before the design phase of the CBT model began, and before each phase of the study, a student information survey was distributed to each student. In total, 180 surveys were distributed over the course of the study from which there were 150 responses, 74 in the classroom at the design phase (74 responses), and thereafter, 28 in phase one (19 responses), 47 in phase 2 (38 responses) and 31 in the final phase (19 responses).

The first page of this survey was drawn up to elicit qualitative data from the students such as student number, spoken languages, years spent at sea, internet access (after hours and at sea if applicable), accessibility to a computer, professional qualifications (if any) and company details (if employed). The language component and computer accessibility portions of this page were of paramount importance.

Pages two and three formed part of the quantitative part of the survey, where students were required to enter the time spent on different vessel classes and time spent working on different types of shipboard equipment. This data was graded on a Likert scale (from 0 to 4 in each category), and from these two pages, an experience rating was computed against the respective student number.

The fourth and final page required the students to read text taken from a prominent Marine Engineering textbook, and whilst doing so, highlight any words that were unfamiliar to them. A word count was done within each profile, and this quantitative value split into (a) English language word unfamiliarity and (b) maritime or engineering terminology unfamiliarity. The reason for doing this was that due to the low levels of experience within the student body, the maritime and engineering terminology would likely have been unfamiliar to them anyway. From these totals, an English language capability rating was allocated against each of the profiles.

(2) Academic marks: After each written assessment and examination, the student marks were uploaded into MAS, entered into the open-source statistical analysis software package Software Open For All (SOFA) and into Microsoft Excel (which served as a data backup and sorting function). From these data storage facilities, data was extracted and placed alongside against each student profile, or to be used collectively in order to view group trends throughout the study. Each assessment and examination results counted for one data point.

For the design of the CBT model (before the classroom phase began), 574 data points were entered, and during the classroom phases 1,513 data points were entered into the respective systems.

In phases two and three of the study, the General Engineering Knowledge and Motor Engineering Knowledge assessments were compiled according to Bloom's taxonomy in terms of the difficulty of questioning. The assessment outcomes were then categorised into each Bloom's taxonomy level, to obtain a snapshot of student comprehension of the subject matter, and to determine if changes to the learning methods used have had an effect on the teaching and learning outcomes.

(3) Peer review of papers: As a result of the lecturer/researcher role held within the action research framework, it was deemed necessary to ensure consistency

with regards to the standard of the assessments if the results were to be considered to be reliable. At the end of the classroom phases, the dates were removed from the final examination papers for the main subject (General Engineering Knowledge), and these were distributed by email to Class 1 Chief Engineering Officers within the industry for an independent feedback as to consistency. Three examinations were distributed at the S4 level (2013, 2014 and 2015). The respondents were required to grade the papers as they perceived them to be from the easiest to the most difficult, and the results from this calculated on a simple Likert scale. One point was allocated to the easiest of the three papers, two points were allocated to the middle paper, and three points allocated to the most difficult of the three papers. The outcomes of the study are then to be viewed against the perceived complexity of the papers graded in this process, in order to provide for an objective perspective so as to further reduce any researcher bias that may exist.

As the number of Class 1 Chief Engineers is limited, a total of 10 sets of papers were distributed by Email, from which there were 10 responses, and a further 2 conducted face-to-face with the SAMSA chief examiners at the Cape Town branch (both past and present). This resulted in a total of 12 Class 1 Chief Engineering Officers providing an independent evaluation of the examination standard in use.

Qualitative data collection

These surveys were primarily designed to test the hypothesis as laid out at the beginning of this chapter. As this study is sequential, the repeated feedback received was used each time to better the software programme in a sequential manner. The qualitative data collection surveys were designed to garner information as to the student perceptions about the current model, and to consider all suggested improvements going forward.

(1) Survey 2: This survey was distributed after the first phase of the study to the S4 students. The three-page survey sought to elicit information with regards to the layout of the system, their personal preferences between paper-based syllabi

and computer-based syllabi, and suggestions that could be used towards future system development.

A total of 28 surveys were distributed, from which there were 12 responses.

(2) Survey 3: This survey was distributed after the second phase of the study to the S3 students. The one-page survey sought to elicit information with regards student preferences given the fact that many have never studied with the aid of a computer before, the volume of work covered within the CBT syllabi and whether or not a CBT model can aid students who have never been to sea before.

A total of 38 surveys were distributed, from which there were 29 responses.

(3) Survey 4: This survey was distributed after the third phase of the study to the S4 students. The two-page survey sought to elicit information with regards the benefits of student interaction from the GBL method, the importance of CBL as used within the class, the volume of work covered and the viability of a CBT system in terms of an aid to students who have never been to sea before.

A total of 18 surveys were distributed, from which there were 13 responses.

The measure of the data collected has been conducted according to the methods described in the following section.

5.6.1 Measurement criteria

The data collected from the initial semester (benchmark before the study began) and during each phase of the study has been analysed to view (a) the outcomes from each phase of the study against the previous phase and (b) the end product of the three successive sequential semesters compared to the initial benchmarked semester. The data was tabled in a nominal manner without any rank order and analysed in the following ways:

(1) Statistical analysis: The mean, the average deviation from the mean, the skewness of the results profile, and the range of results were tabled, along with

the average class experience levels from the population sample for that particular group.

With all the data from the groups tabled, a t-test has been done with the data from each phase to test to ascertain if the data received demonstrated differences of a random nature, or if the differences between the groups demonstrate that the data groups can be considered to be statistically significant. These tests were done manually in Excel using the collected data from each phase, with the calculation involved being shown as Appendix 5.

(2) Pearson's *r* correlation: The student experience levels were graphed alongside the assessment and examination outcomes for that profile to determine the degree of correlation (if any), and to gauge changes to the strength of the correlations over the course of the study. This would provide an indication that the study may have had on the lesser-experienced students within the group.

(3) Proficiency growth model: Assessment and examination marks of 50% and above (over the course of the study phase) were tabled to determine changes in the proficiency rate over the duration of the study in its entirety.

(4) Performance index model: The assessment and examination results were demarcated into different categories to determine which section of the population sample fared better than other sections. These categories were (a) less than 40%, which is deemed to be a fail, (b) 40% to 49%, which allows the student to write a supplementary examination, (c) 50% to 74% which is a subject pass and finally (d) 75%+, which is a pass with distinction.

(5) Simple growth model: In order to address the limitations associated with the different student groups (and student abilities) being compared, use was made of the simple growth model that tracks the same students who are doing their S3 and S4 studies in successive semesters. As the same student's outcomes are monitored over successive phases of the study, it is intended that the outcomes be more reflective of the method that was used.

(6) Blooms taxonomy assessment: In the second and third phase of the study, the assessments for the core subject of General Engineering Knowledge were set

to accommodate questions from the first five levels of the Bloom's taxonomy scale. The reason for doing this was to determine if a higher level of understanding was forthcoming from the method in use in comparison to the pervious semesters that largely used questioning from the lower levels of the Bloom's taxonomy scale. The highest level according to the Bloom's taxonomy scale was not used (the creation of knowledge) was not used, as this level is deemed to fall outside of the competencies required of students at a diploma level.

(7) Peer review of papers: To further reduce researcher bias, the final outcomes from the analyses above are to be viewed alongside the outcomes (difficulty grading) from the peer review of the examination standard that was place for the semester.

The measurement instrument criteria have been administered in a similar manner throughout, using a predetermined schedule at each phase of the study in order to ensure reliability and validity of the research data. The test-retest method below details the data collection timeframes involved.

5.6.2 Reliability

For the S3 students, the assessments were conducted in March and May, with the final written examinations taking place in June. For the S4 students, the assessments were conducted in August and October, and the final examinations took place in November, for each of the study phases.

To ensure reliability of the measured data, the assessments all followed a similar pattern and comparable standard throughout, with the assessment papers being placed on review by SAMSA at any stage.

- The examinations were moderated internally at the S3 level by Mr. E. LaVita (MSc – Maritime Technology & Education, WMU), and at the S4 level by Professor E. Snyders (PhD, HOD of the CPUT DMS).
- After this internal moderation process, the S4 papers (exit level) were sent to SAMSA for external moderation. The moderation was done by Mr. P. Baxter (Chief Engineer CoC, Senior SAMSA examiner Cape Town).

- Further steps to ensure reliability included the distribution of the General Engineering Knowledge papers that used over the course of the study by Email to serving Chief Engineers within the industry in South Africa, and to a past senior SAMSA examiner for an independent quality assessment, as described previously.

5.6.3 Limitations associated with being an insider researcher

The limitations associated with a study of this nature are largely as a result of the method used, and the circumstances that prevail within a developing country such as South Africa. These limitations are listed as follows:

(1) This study has been conducted through an action research methodology, which does not allow for a separation between the lecturer and the researcher. The fact that one person is responsible for setting and delivering the course material, assessments and examinations, and then carries out research into the outcomes of these methods is noted, and in this regard, to ensure rigour and reduce researcher bias, methods have been developed to negate this (triangulation). The lack of resources within a small maritime nation means that within South Africa, only two lecturers are authorised to deliver tuition at the management level for Marine Engineers by SAMSA, one in Cape Town and the other in Durban, 2,000 kilometers from Cape Town. Through ensuring the process remains transparent, through having the instruments evaluated via a two-stage moderation process and later peer-reviewed, and by having the outcomes of the findings critically evaluated, the study aims to ensure academic rigour.

(2) Taking the form of a case study conducted at a single institution places restrictions as to the transferability of the study into other locations. Realistically, it would not be possible to expect another lecturer to implement an 18-month study of the entire Marine Engineering syllabi devised by someone outside of their institution. Concept mapping studies that have been conducted elsewhere are mostly limited in population sample numbers, run over the duration of a few weeks and focus on a single topic.

(3) It was important that construct validity be achieved as much as possible, which became a key driver for the collection of multiple sources of evidence through the various data collection methods used (surveys, interviews and quantitative data). The specifications of the units of analysis as used in the quantitative data collection process, was intended to present the outcomes in terms of student academic results in a manner that could ensure internal validity though objectivity. External validity is more difficult to achieve in a single case study, however it is possible to achieve external validity through the theoretical relationships that exists with the data collected; and from these relationships, generalisations can be made (Tellis, 1997). Validity from the research is strengthened through focusing on the learning theories that the chosen learning methods are built upon, developing ways to test those methods, and looking at the outcomes from a larger perspective than purely that of maritime education.

(4) Donmoyer (2000) poses the following question with regards to the generalisability of a single case study findings, namely: ‘How does in-depth knowledge of a single case help us understand and act more intelligently in other potentially different cases?’ Lincoln and Guba (1985) prefer to talk of the term ‘transferability’ as opposed to the term ‘generalisability’, stating that at best, a researcher can only supply information about the studied site and make judgments about the transferability of the research findings to another site. The final judgment of transferability is vested in the person seeking to make the transfer.

(5) Further limitations arise from the different sample groups within the study, in that (a) the study is not conducted with successive student groups (1st semester S3 and 2nd semester S4) and (b) the students within each group have different abilities. In terms of the students having different abilities, the experience grading for each participant has been tabled, and used as factor to look comparatively at the respective groups to offset these limitations.

(6) A final limitation comes in the form of an authoritarian stance, with the researcher holding the position of Chief Engineer, and the study participants serving at lower ranked positions within the shipping rank structure.

A de-limitation was set with regards to the professional peer-review process of the examinations standards, in that only the General Engineering Subject was evaluated externally (by Class 1 Chief Engineers within the industry). The reasoning behind this was (a) The General Engineering Knowledge component is the core subject, with Motor, Steam and Electrical being regarded as secondary subjects and (b) to distribute 12 examination papers by Email to peers within the industry would likely return less of a response due to the work involved on their part. The results tabled within the findings reflect a separate portion where the General Engineering subject results are tabled separately, and viewed in light of this peer-review process.

5.7 Ethics approval

The student information was gathered through the use of one (or more) of the four qualitative surveys distributed at the appropriate times during the course of the study. Participation in the surveys was purely voluntary, with the agreement that no personal information would be disclosed whatsoever. Approval of the format that the surveys were to take was obtained from the WMU ethics committee at the onset of the study.

For the student information surveys (survey 1) that were conducted at the start of each phase of the study, the students were briefed about the particular study that was taking place prior to completing the written survey. Those that chose to partake, were asked to read the first page of the study which explained the purpose of the study, as well as how the data provided would be used, and disposed of, after the study had been completed. Once understood, those participating were asked to sign acknowledgement that written consent was given to use the data provided in the survey.

Similarly, with regards to the information surveys that were to follow (2, 3 or 4) at the end of each semester, participation was again voluntary, and conducted in the same manner as the initial data gathering survey at the start of the semester (survey 1).

Data records have been processed in the strictest confidence, and are to be destroyed at a time when reference to them is no longer a requirement.

Summary

The process of gathering student information data, as well as assessing the technology and computer infrastructure available to both the students and the institution followed. This information was vital in defining the scope and complexity of the CBT system that was to be developed.

CHAPTER 6

CPUT AND STUDENT NEEDS ANALYSIS FOR THE DEVELOPMENT OF A CBT MODEL FOR MARITIME EDUCATION

Introduction

One of the primary future aims after the culmination of this study is to develop a CBT model that can aid Marine Engineering students at all levels, through addressing the identified shortcoming with traditional MET tuition in South Africa as a result of the environment. This includes catering for all Marine Engineering students right through from entry-level students (Engineering Cadet level theory) to the exit level students (Chief Engineering Officer level theory). It is therefore deemed important to review the needs of the more junior level students that enter the system at the operations level, who proceed to embark on a maritime career.

6.1 Students at the operations level: Watch-keeping Officer candidates

The younger generation of higher education students that enter the CPUT DMS were mostly born in or after 1982, which places them as part of a new generation of learners often termed the "Net Generation", the "Digital Generation" or the "Y Generation". On the whole, this group stems from a time when families started to become smaller than any generation that had come before them, and in this regard, a sense of entitlement exists. Having grown up with customisable technology, this generation prefers a more fluid approach to learning. The generation is also blessed with good communication skills, which has resulted in a preference towards teamwork and peer-to-peer dialogue, rather than working alone (Gardner & Eng, 2005).

Many believe that a need exists to examine the way that knowledge is delivered and learned with younger students, if the cultural divide between the lecturer and today's generation of students is to be bridged (Weiler, 2004). Having grown up with technology more than any other previous generation, this generation is comfortable with a more visual style of learning than may have previously been the case. This preferred style may however be in contrast to many of the traditional teaching methods that are in place within the classroom. This digital generation favours a system that brings together material from different sources, that are presented through a single user interface (which a CBT model can provide for), and that serves to act to some extent in a similar manner to an internet search engine.

Both achievement and winning are important traits of a younger generation student, and as such, many will quickly become frustrated through certain experiences that they perceive to have no obvious outcome (Eisner, 2003). Due to the environment in which these students have grown up, the generation as a whole is generally well informed and opinionated. In order to engage with these students, it is essential that their interest in the subject material be maintained. This can be achieved via the raising of interesting questions, stimulating debate among the students, and through participative activities as opposed to the established lecturer/student classroom relationship that often exists. In essence, the lecturer is likely to achieve better student learning outcomes through adopting more of a facilitating role, rather than taking on a less embracing lecture-based stance to education. As a generation that has grown up with the internet, and being one that generally prefer wider extensive reading in smaller amounts as opposed to more focused intensive reading, the syllabi development needs to include material from numerous sources. In order that the syllabi retain the interest of the student it must be attractive to the eye, it must be sufficiently engaging to hold their interest and foster participation, and should be able to provide instant feedback to the student as and when feedback is required.

One challenging characteristic of today’s younger student is that the work ethic is generally not as strong as has been the case with previous generations, as they prefer a more informal approach to their work as opposed to rigid guidelines (Reilly, 2012). It is believed that the generation has in some respect abandoned certain responsibilities with regards to taking accountability for their development (Shaw & Fairhurst, 2008), which is something that would need addressing when CBT syllabi are compiled. Training or educational programs will likely come in for criticism from these students if the personal outcomes are not as they had expected, without actually acknowledging that they may personally be at fault, or that they did not put in sufficient work with their studies.

Research conducted by the U.S. Department of Education found that this generation is reading and writing less than any other generation previously did, and that they are doing these activities less well. Because of this tendency to read less, these students tend to have adapted a more visual learning preference, and are referred to periodically as ‘screenagers’ (Reilly, 2012). One way to promote the reading component of their studies is to make the reading material as modern and as relevant as possible. This however can present somewhat of a challenge in MET circles, as very often the library sources contain dated information. It is in this regard that internet sources on modern-day shipping issues and engineering systems have particular relevance, with a CBT model of education being easily able to co-ordinate these various sources within the curriculum. Provision of material in this manner also aligns the curriculum with another of the younger generations traits, in that they tend to be more holistic in their reading choices as opposed to being analytical. These students are much more likely to start embarking on extensive reading from multiple sources as opposed to doing intensive reading from a limited selection of material.

One concern observed at the CPUT DMS with the younger generation student is that much of the technology preferred by the students is in the form of smartphones and smaller handheld electronic devices as opposed to laptops computers. Very often the students take down the notes that are written on the whiteboard by taking a photograph on their smartphone. The obvious concerns with this practice include (a) the fact that the students are not writing down this material and thus not working through the problems, and (b) are these notes actually worked through at a later stage by the students of just left among the many other photographs on the phone? A worrying concern is that while this practice appears somewhat strange at a higher education institution, it may possibly align itself with the type of schooling the student had been used to before they entered an institution of higher learning.

Additionally, questions need to be asked as to how the technology that the students have grown up with has been used by them. For example, has technology been primarily used for social media purposes (Facebook, Twitter etc.), or have they ever actually embraced the use of technology for study purposes? For many of the students, especially those from lesser-developed regions within Southern Africa, the use of technology within a classroom is something completely new to them.

6.2 Computer literacy

As South Africa is developing as a nation, vast differences still exist with respect to the quality of education that is received within the different regions within the country. The more affluent students will likely have used computers at school for educational purposes, however for the majority of the students this may not have been the case. Smartphones and tablets are used by many of the students at CPUT for communication and social media purposes and other items not related to education, with many of these students opting for these devices over purchasing a laptop computer. Only a small proportion of the student intake at the CPUT DMS will have attended secondary schools that have used technology extensively in the classroom. These students would naturally be less comfortable with using computers than their fellow students who enjoyed a better quality of education.

Self-efficacy can be defined as a belief in ones own ability to “mobilise the motivation, cognitive resources, and courses of action needed to meet given situational demands” (Wood & Bandura, 1989). Computer self-efficacy places this belief in a computerised environment, referring to a belief in ones own ability to use a computer effectively. Students who lack confidence in this ability may produce poorer outcomes when computer-based tasks are involved, and similarly, students that have strong computer skills may view computer-based courses as being relatively easy. Students with lesser computing skills may suffer from a form of computer anxiety, and that these negative sentiments towards computer use may detract from the cognitive resources at their disposal, and as a result, perform more poorly when conducting certain computer-based tasks (Kanfer & Heggestad, 1997).

In order that computer use in a classroom environment can become an effective teaching and learning tool, the students’ attitudes towards the use of computers should be assessed so that they can recognize the benefits of computer use for study purposes. It is also prudent that higher educational institutions that make use of CBT programs provide short courses in the use of computers and the software for the specific applications that require their use. For those students that are relatively new to computer aided study programs, the adoption of a CBT model that can look and feel like a website (in terms of navigability and the use of extensive graphics) would help to make the transition process easier for them.

6.3 Updated technologies

Technological resources have the ability to aid pedagogy through the provision of impressive visual imagery, organised print and the compilation of tasks that are able to promote virtual experiences. Technology use in education has the ability to encourage self-reflection and self-evaluation, whilst promoting a collaborative information-sharing environment among the class. Through making various technologies available to the students, they are better able to learn in ways that they find the most effective and befitting of their preferred learning style, thereby ensuring the process of learning does not become a ‘spectator sport’ (Chickering & Ehrmann, 1996).

Technology can be used in education in three primary ways to promote active learning, namely (a) to facilitate the learning process by doing, (b) to learn via time-delayed exchange of information and (c) for real time conversations about the subject matter.

Moving outside of the classroom environment, the use of technology has many advantages in higher education. Firstly, the information flow process can continue after the direct lecturer and student contact time within the classroom has finished. This provides a beneficial medium of communication for those students who are shy or reluctant to ask questions whilst they are sitting in the class. This may be primarily down to the fact that it is often easier for certain students to discuss items in writing, as opposed to discussing them orally, where ambiguity may play a part in the discussion process. Secondly, for those students who are not as comfortable in conversing in English, the use of technology affords both parties time to interpret what has been said, time to digest the information and finally time to compose a suitable response.

In order that the focus could shift towards choosing or developing the correct type and use of technology for the students at the CPUT DMS, it was required that more information be gathered about the type of student that gets admitted to the various Marine Engineering streams at the institution. This data would highlight both the strengths and weaknesses in terms of the available resources accessible by the students, and the abilities of the students to embrace the use of computers for the purposes of study.

6.4 CPUT student needs analysis survey

A student analysis survey[59] was drawn up and distributed among the students before the initial build-process of the CBT model began. The purpose of this survey was to garner as much information as possible (about the students) to use for the developing of an appropriate CBT system. This information gathering survey was intended not to becoming a laborious task for the respondents to complete, in order that it become reflective of the majority of the students through participation rates. In order to ensure that an ethical data collection process could be ensured the survey was approved by WMU's ethics committee before prior to being distributed among the students. Data collected from any of the students included their name and student number, as it was a requirement at a later stage to capture assessment marks against each student's portfolio. Any personal information obtained was only for record keeping purposes, no personal information was disclosed in any form to any parties, and the information was disposed of after the study outcomes were accepted and documented.

In order to obtain data that was relative to the three different phases of the study, questions were categorised into three main sections. These included (a) information regarding the student and their ability to operate an online study course, (b) there was an experience related information section to gain an understanding of the competency levels among the students, and (c) an English language capability assessment was included. At a later stage (once assessment results became available), these assessment marks were loaded against each student's profile to determine the correlation that may or may not exist between prior experience and the academic results obtained, and between their English language capabilities and their academic results obtained. The results in terms of the assessment outcomes (percentages obtained) were captured against each respondent's profile. These assessment outcomes included both the written assessments that were conducted during the course of the semester, and were also to include the final written examinations across the four primary subjects of General Engineering Knowledge, Motor Engineering Knowledge, Steam Engineering Knowledge and Electrical Engineering Knowledge.

[59] Student analysis survey: Appendix 1

Section 1: Student computer ownership and after-hours internet access capability

The primary importance at the initial stages of this study was to gain insight regarding the capabilities of the students to utilise the selected CBT/LMS model of education that was to be introduced. Questions relating to the student ownership of laptop computers, and their access to the internet after classroom hours produced interesting results, which had a dominating influence over the form that the model was to take. Similarly, a question regarding onboard internet-access indicated positive results in terms of seagoing internet-access among the population sample, however once queried, it was shown that the data transmission restrictions that the shipping companies have in place would exclude any form of online learning resource use for these students whilst at sea.

Many students indicated that they owned tablet computers, however the limited functionality of these in terms of being a participative learning management tool (due to a limited screen size on most devices), meant that the preferred option would be a laptop computer. During the course of this study, CMapTools introduced a version that was compatible with tablet devices, however this was not used due to the selection of menu items being problematic as a result of them being too small in relation to a touch-screen finger size pointer.

CPUT's maritime campus is looking at developing a computer-based Marine Engineering facility in the future, however the form and the choice of technologies used will depend on the outcomes of studies of this nature.

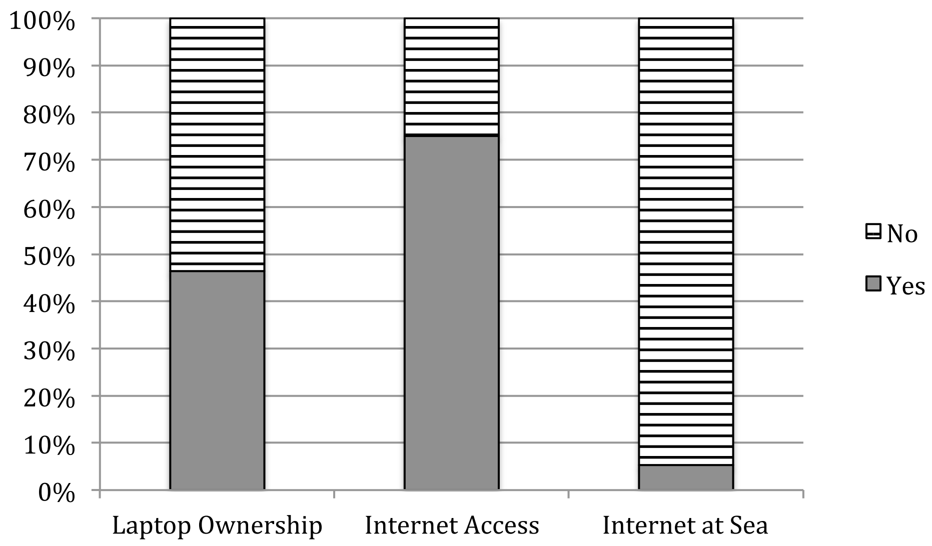


Figure 13: Chart - S1 Student computer ownership, after-hours internet availability and accessibility to the internet when last at sea[60] - *56 surveys received*

At an junior level (S1), 26 of the 56 students surveyed stated that they owned a laptop, whilst 42 of the 56 students surveyed stated that they have access to the internet after hours. This access includes smartphones and tablet use. Only 3 of the 56 students indicated that they had internet access on the last vessel they sailed on. This is a very small number, but when viewed in perspective that only 5 of the 56 students in the class had ever been to sea before, the number is actually over 50% of the seagoing students had internet access on their last vessel they sailed on.

[60] 2-20MB data limit restrictions for seagoing staff.

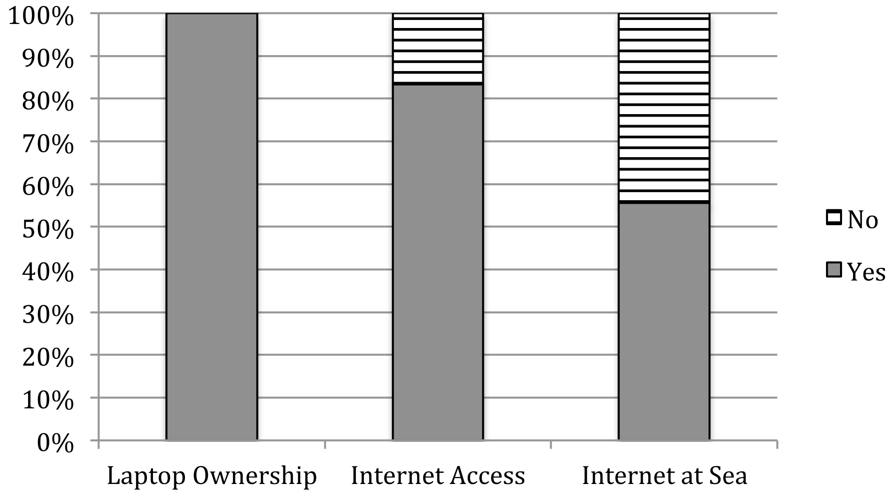


Figure 14: Chart - S3 Student computer ownership table; after-hours internet availability and accessibility to the internet when last at sea[61] - *18 surveys received*

At a senior level (S3), all 18 of the 18 students surveyed stated that they owned a laptop computer, whilst 15 of the 18 students surveyed stated that they have access to the internet after university hours. This access includes smartphones and tablet use, and included the foreign student component residing in a residence without an internet facility. This shortcoming can be addressed through these students either taking out a wireless 3G contract from a local cellular phone operator, or through assignment completion after hours, and later assignment submission once connected to CPUT's wireless network. 10 of the 18 students indicated that they had internet access on the last vessel they sailed on, but that this was limited internet access in the range of 2 to 20MB of data transmission allowance per day for seagoing staff. These limitations would make access to an internet-based curriculum impossible for study purposes whilst serving at sea.

Combining the junior and senior level students, 44 of the 74 surveyed students owned laptop computers, which equates to only 59,46%. As a result of these findings, and owing to the lack of classroom infrastructure, this study was conducted only at the

[61] 2-20MB data limit restrictions for seagoing staff.

senior level (Second Engineer (S3) and Chief Engineering Officer (S4) levels), as these students are better equipped in terms of meeting the course requirements (laptop ownership). Recognition for this choice was, in part, due to the diverse (unequal) backgrounds of the students in attendance at the CPUT DMS, and the disparity that exists among the income levels and subsequent ability to compete on an equal footing with their peers. If adopted for use after this study has concluded, entry-level computer allocations could form part of the course program.

Data derived from the initial round of surveys had the deciding factor as to the choice of CBT/LMS model that was adopted for this study.

Section 2: Student experience level analysis

The second part of the survey included a two page Likert scale questionnaire regarding the experience levels of the individual students. This was split into (a) the vessel types that the students had previously sailed on and the years of experience gained for each of the different class vessels, and (b) the different types of onboard machinery that the students have been exposed to, and the years of experience that were gained in those fields. These values were then allocated a numerical score according to the Likert scale, which was used as part of a correlation study to ascertain whether or not greater experience levels resulted in better academic outcomes (grades).

This assumption became evident when the two groups of S3 students were compared in successive years from 2014 (students who all had some form of prior seagoing experience) to 2015 (where some of the students had no prior seagoing experience).

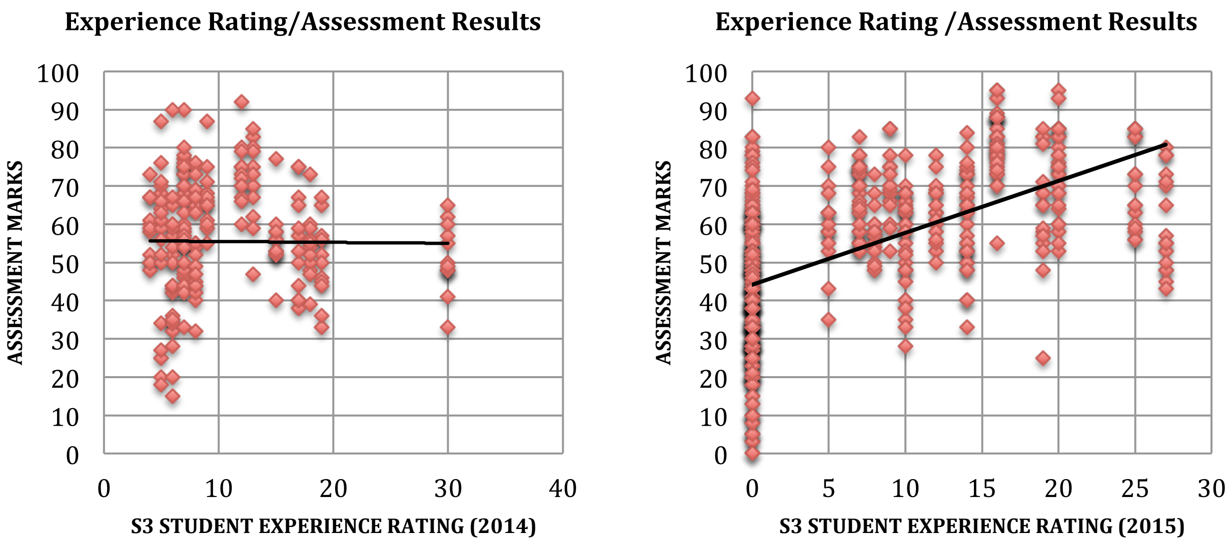


Figure 15: Chart - Student marks vs. experience correlations (S3: 2014 & S3: 2015)

In conjunction with these findings, this information was useful for developing the case-based component of the course (CBL), which was primarily aimed at hands-on knowledge and the management of onboard procedural affairs.

At the junior level (S1), only 5 of the 56 students surveyed stated that they had been to sea before, which equates to a total of 8,8% of the population sample. The students that had been to sea before were allocated marks according to their exposure to different forms of shipboard systems. The large contingent of students who had no prior seagoing experience had an obvious impact on establishing what correlation existed between prior experience and academic marks obtained. For this reason, only those students at the senior level are used to determine what correlations exist for this study.

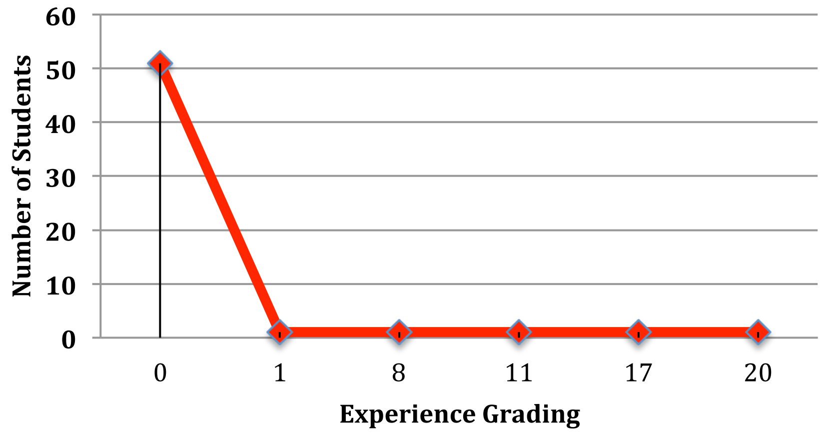


Figure 16: Chart - S1 Student shipping experience levels (2014) - *56 surveys received*

At the senior student level, the results were wide ranging between a lowest allotted valuation of 4 through to the highest being that of a rating of 30 for the 18 students that took part in the survey. Most notably, every student in this particular intake had some form of experience upon entering the senior level study stream. The experience levels as determined were used for comparison with the individual assessment scores that the students attained in order to determine what experience/academic marks correlation exists.

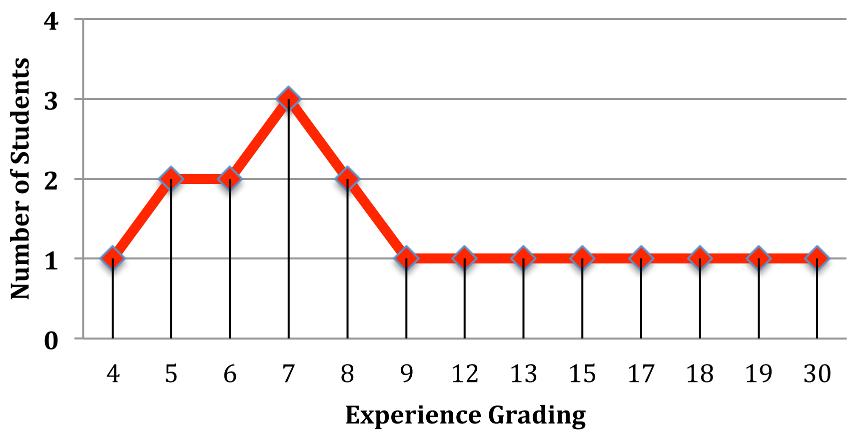


Figure 17: Chart - S3 Student shipping experience levels (2014) - *18 surveys received*

Section 3: Student English language proficiency analysis

The final component of the survey contained both qualitative and quantitative aspects of literary analysis. With this part of the survey the students were presented with a page of text straight out of one of the Marine Engineering text books in use, and they were asked to highlight any words that were unfamiliar to them. The unfamiliar word count from these surveys was totaled, and divided qualitatively into two groups. One group contained those words that were deemed to be maritime related or technical in nature, and the other represented unfamiliar words that were not deemed to be maritime related or technical in nature. The reason for splitting the word count up in this manner was due to the high number of students who had not been to sea before. If a student had no shipping experience, they would naturally be unfamiliar with the maritime related and technical wording contained within the text.

The outcomes for this language component of the survey, was to assess whether or not a need exists to add a language assistance function as an add-on to the developed CBT/LMS. Furthermore, data was required in this regard in order to assess the outcomes of the collaborative learning phase of the study (GBL), where student groups are focused around reducing the language differences that prevail.

At the junior student level (S1), the home languages among the 56 students surveyed were recorded as follows: 8 Afrikaans students (14%), 1 Djiherero student (2%), 13 English students (23%), 2 Oshiwambo students (4%), 13 Portuguese students (23%), 1 Setswana student (2%), 1Tshivenda student (2%), 13 isiXhosa students (23%), 1 Xitsonga student (2%) and 3 isiZulu students (5%).

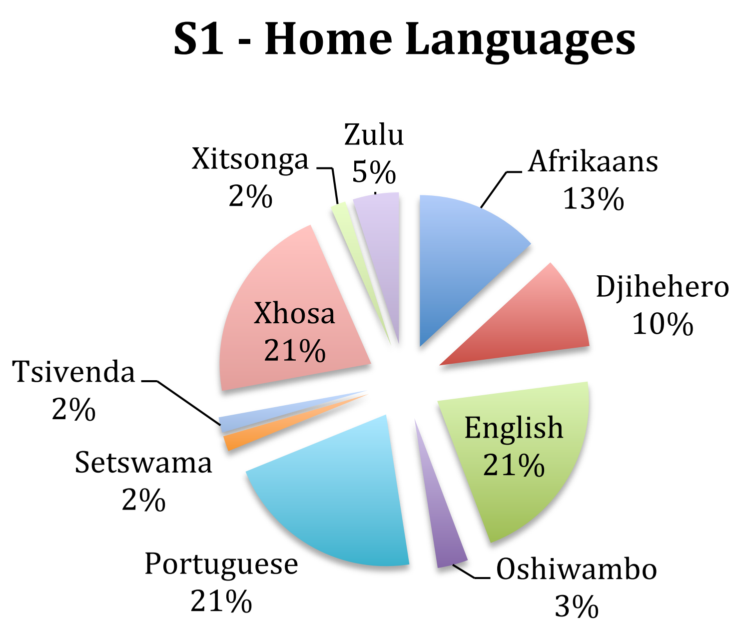


Figure 18: Chart - S1 Student home language analysis - *56 surveys received*

At a senior student level (S3), the home languages among the 18 students surveyed were recorded as follows: 2 Afrikaans students (11%), 6 English students (33%), 2 Sepedi students (11%), 2 Sesotho students (11%), 2 Setswana students (11%), 3 isiXhosa students (17%) and 1 isiZulu Student (6%).

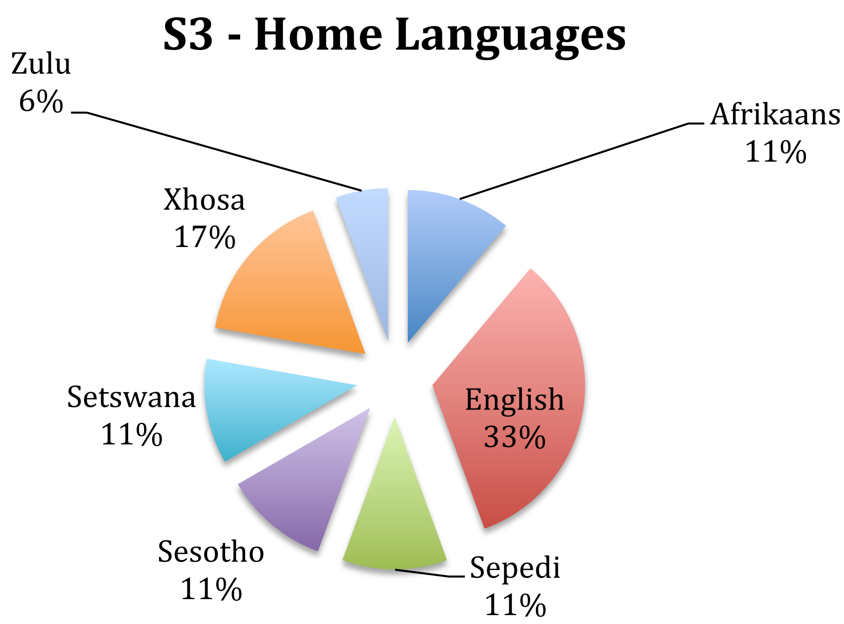


Figure 19: Chart - S3 Student home language analysis - *18 surveys received*

Findings of the student analysis survey in terms of assessment outcomes

(a) Prior experience assessment

Data collected from this survey included those groups in the first semester (S1 and S3) and the second semester students (S4) for the 2014 calendar year. The captured experience ratings that was allocated to each student (Likert total) were updated as assessment results were finalised. A total of 574 data points were inputted for the entire group, were analysed and graphed in a scatter formation. This was done primarily to ascertain if a correlation existed between prior seagoing experience and academic marks.

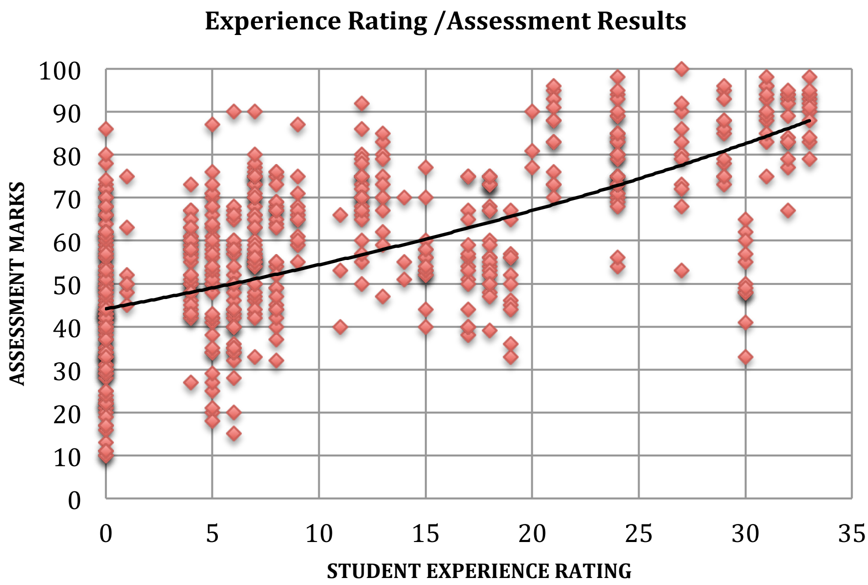


Figure 20: Chart - Experience rating to assessment results obtained – 574 data points

For this phase of the data collection, in order to get representation across all students enrolled for the 2014 calendar year, all of the student experience levels were included. Once the respective academic assessment marks were allocated to each of the profiles, the findings confirm a positive correlation to exist between prior experience gained by the students and assessment outcomes attained. As a result of this analysis, the detailed findings from this survey largely supported the belief that a lack of seagoing experience levels and academic outcomes at the CPUT DMS are correlated.

(b) English language proficiency assessment

The survey comprised a page of sampled text from one of the leading maritime engineering publications in use at the institution, which had a total word count of 455 words. Out of a sum total of 33,670 words, the 74 respondents highlighted 234 words that were unfamiliar to them (0,69%). Once subjectively analysed, the 234 words were categorised as comprising 180 maritime or technical words (0,53%), and 54 words (0,16%) being purely English language terminology. Once clarified these proportions were significantly lower than initially anticipated, especially given the group cultural and language diversity.

Data collected from this survey was included in the profiles, and the profiles were later updated with results obtained from the first assessment conducted at the start of the course in 2014. Findings from this analysis confirm a negative correlation between English language proficiency, both in terms of the overall word count (left), and the word count with all the technical and maritime related terminology discounted (right). The fact that the negative correlation is less pronounced when the maritime and technical wording is removed from the sample indicates ambiguity as a result of a lack of prior industry exposure.

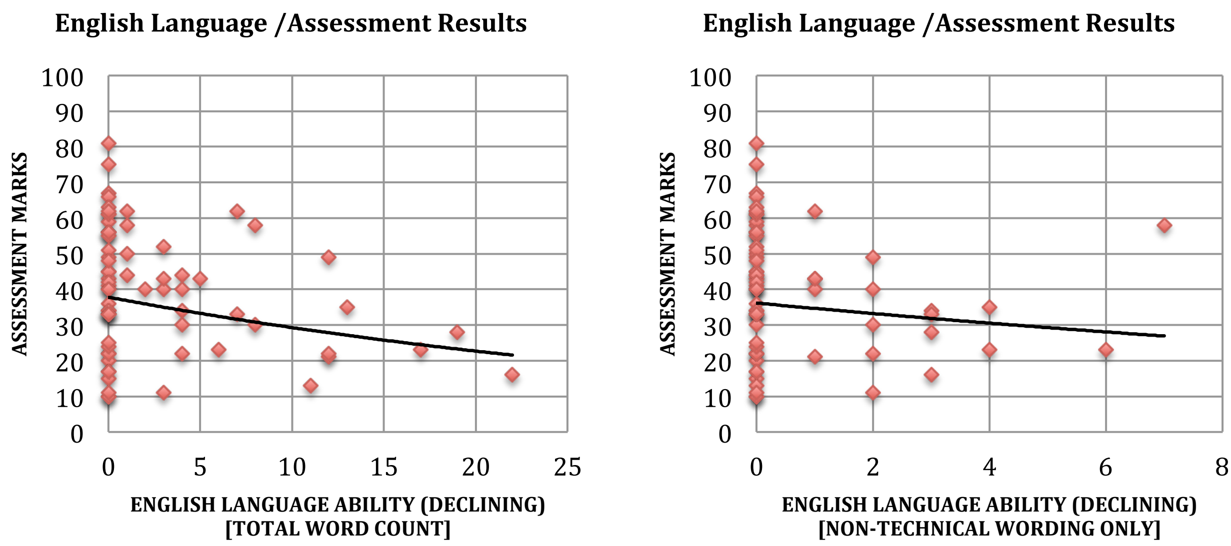


Figure 21: Chart - English language proficiency to marks obtained
Overall word count (left) and Word count with maritime and technical related wording discounted (right) – 74 surveys received

These findings agree with Cardeño's (2004) research findings regarding English language proficiency and academic assessment outcomes. With an increasing scale on the x-axis reflecting a decreasing level of English language competence, it can be seen that the regression line drops away in terms of assessment results as the language competence declines. This confirmation was beneficial for the formulation of the study material for the latter part of the study, which is to include the various learning approaches of case-based tuition methods and collaborative teamwork, and for the formation of a syllabus delivery method that could meet the needs of both the students and the institution.

6.5 Blended learning systems: The need for flexibility

The term 'blended learning' was in the past often used to describe a medium of education that catered for both in-class tuition and an e-learning environment, with the latter being utilised remotely after classroom hours. A more modern approach sees blended learning referring to a system whereby subject material delivery is conducted by more than one mode. This may have the benefits of simultaneously ensuring that the learning outcomes can be enhanced whilst at the same time the costs of the program delivery can be reduced (Singh & Reed, 2001).

Blended learning systems can take numerous forms, and can be defined in different ways, as a system that (a) is able to combine different sources of media, (b) that can combine different methods of instruction and (c) can combine face-to-face tuition with online instruction (Graham, 2006). As most learning systems combine different instructional methods and media sources, the definition adopted for this research is based on the third point described by Graham (2006) as being a more accurate definition, namely the combination of face-to-face tuition and online participation.

It is believed that technological advancements have led to increased levels of computer integration within classroom tuition, as technology has the ability to enhance pedagogy through affording access to a wider range of material (Graham, 2006). The movement away from traditional transmissive learning methods towards more interactive learning methods has been aided through the use and integration of technology. Both online and offline forms of e-learning can be incorporated into a blended learning system. The use of the intranet, or resident based computer information can drastically reduce data transmission costs, whilst speeding up download times. This could be supplemented if need be by an internet based CBT model that is accessible after hours, to fulfill the needs of both course content and participation forums for active involvement on the part of the students.

In any environment, it is the external circumstances that can have an overriding impact on the effectiveness of the outcomes. With regards to the South African environment, the model of blending online and offline learning becomes appealing for the following reasons:

- Many students do not have access to the internet at home or their place of residence, making the concept mapping option (with the information resident on the students computer) desirable.
- The cost of data transmission is relatively high in South Africa, with data transmission speeds being relatively slow in comparison to Europe for example. This again makes the concept mapping option an attractive choice,

as the syllabus can be loaded in bulk onto the student's laptop via an external hard drive or distributed via a data DVD.

- The medium of email can be used to send files via satellite to vessels as required, allowing for the student to easily import documentation into their resident CBT software (concept mapping). Similarly, student exported material and concept map assignments can easily be submitted to the lecturer via email in PDF format, for the perusal by the course lecturer. These files are small enough to be sent via satellite transmission, without accruing the prohibitive satellite data transmission costs that would occur with an internet-based system.

Another form of blending comes about as a result of the different methods that the learning process is done within the classroom. Self-paced learning methods can be supplemented by collaborative learning methods, thereby serving the purpose of fostering a communicative knowledge-sharing environment among the learners (Singh, 2003). The informality that can accompany a collaborative approach can develop unstructured learning patterns through dialogue, to compliment a more structured content-based curriculum delivery system.

Self-paced learning occurs by the student using the CBT model and completing the tasks and assignments at their own pace. Being able to progress at their own pace means that the information is received by the student at the optimum time within their cognitive understanding of the topic. Following on from this process, and interlinking with this process, comes the collaborative phase. Here the students are able to interact and bring forth their ideas and understanding of the subject matter, to apply the principles towards the completion of designated group tasks.

It is essential that the student profile, subject content, financial and infrastructure constraints be analysed before the actual content delivery modes are developed (Singh & Reed, 2001). Through a successful marriage of the right course attributes the proficiency in terms of the student outcomes can be optimised, and the (sometimes complex) mix of attributes among students at higher educational institutions can be better catered for. Sharpe et al. (2006) agree with Singh and Reed (2001) in that for the design of a blended learning system to have any success, it needs to cater towards the needs of the community and the particular organisation, as opposed to following any generic format. The classroom design elements as used for this study, and the development of the CBT program in order to meet these requirements, is described in the section that follows.

6.6 Contextualised justification for the choice of CBT model used

Taking all the necessary requirements into account, the choice of software model that was adopted for this study was developed specifically to be independent of any internet connection, although periodic email accessibility was a requirement. This choice is in line with the findings of Erasmus et al. (2010), who state that the choice of systems for implementation in South Africa have largely been dependent upon the availability of technologies, student access to hardware and software, and adequate bandwidth being available. A further reason for choosing a system that ran external to CPUT's servers and IT infrastructure was that (a) substantial hardware procurement would be required by the institution for this study to take place, and (b) the success would be (in-part) reliant on the system support element that accompanies a LMS or CBT model of education run on institutional servers.

It is sometimes the case (at the senior student level) that the students' employers require them to do brief stints at sea to help out with staff shortages in times of need. Should these students assist their companies in this manner, the lack of bandwidth availability whilst at sea would mean that the student would not be participative in the assignment process, but would be required to catch up any missed work upon return to class. With this in mind, preference was given to the development of a CBT model that could make use of minimal bandwidth, thereby making it possible for students for study whilst at sea and maintain their involvement. Sixty percent of the 2014 management students surveyed reported to having an onboard internet connection, however they stated daily data transmission restrictions in the order of 2 MB per day. This hindrance, made an internet based LMS or CBT model not a feasible option. This limitation in terms of allowable bandwidth would mean that the transmission of the required media files over the internet can be problematic due to both the data transmission speeds and data transmission costs, as well as being over the allowable limits in terms of daily bandwidth allowances for seagoing staff.

After weighing up the merits of the various options, the preferred choice for the syllabi development was chosen in line with what has been done previously at Singapore Maritime Academy (Chatterjea and Nakazawa, 2008), namely the concept mapping based CBT software[62].

FINDING	Internet-based LMS/CBT Model [Proprietary] *Blackboard/Moodle*	Resident-based LMS/CBT Model [Open-source] *CMapTools*	Independent Website (LMS) [Optional] *Custom Built Website*
Institutional Costs	Proprietary: Software licensing & hosting costs	None: (freeware) Open-source software	Lecturer costs: Website development & hosting
Student Costs	Internet data transmission costs (standard)	Email data transmission costs (limited)	Internet data transmission costs (standard)
IT Support Requirements	Yes	No	No
Internet Access Requirements	Yes	No	Yes
Email Requirements	No	Yes	Yes
Data Transmission Requirements for Seagoing Use	Full internet access required	Email access required	Full internet access required
Student Customisability of CBT Model	No	Yes	No
Lecturer Transferability of CBT Model	Yes	Yes	No

Figure 22: Table - Comparative analysis of various software options for CBT use

62 Referred to by the authors as a Knowledge Management System (KMS)

There are numerous benefits associated with the use of this platform to conduct this research, which include the following:

(1) The software used (CMapTools) was available as a free download from IHMC, being an open source university initiative development. The software and accompanying rights for free educational purpose distribution was purchased IHMC directly. In addition to the software being open-source, the course material has been formatted to work without expensive proprietary software to run any of the applications, and includes the use of freely downloadable PDF viewers (freeware), and freely downloadable VLC media players (also freeware). This makes the cost to the individual students zero in terms of software installation costs, something that is important in the absence of classroom CBT infrastructure at the CPUT DMS.

(2) The CMapTools flexibility allows for the course material, comprising text, images, animations, movie clips, brochures, and assignments to be stored on a portable hard drive, (or distributed data DVD) and loaded onto the students computers once the CMapTools software is up and running. This folder, that contains the entire course content, remains resident on the students' own computers for the duration of their studies, essentially making the need for an after-hours internet connection obsolete. CMapTools has been extensively developed to run on basic or less expensive laptop computers, which further acts to improve the CBT usability for the students.

(3) Correspondence between the lecturer and the student is conducted via email when the student is away from campus for any length of time (due to work commitments). In a similar manner, the weekly assignments (once completed) are exported as a limited size PDF email attachment and mailed to the lecturer for review and assessment. Furthermore, additional course notes and supporting material that complement the loaded CBT syllabus can just as easily be sent via email to the students, and once received by the student, can be imported into the holding folder that remains resident on the students hard drive. The documents that are imported in this way become available to the student the next time they start the program. This feature is beneficial in ensuring that future distance study for seagoing students remains a possibility.

Differences between the SMA and the CPUT DMS CmapTools platforms

In the case of the SMA, the CmapTools platform was used to facilitate a liquefied natural gas (LNG) conversion course for senior experienced engineers. At the CPUT DMS, the CmapTools platform was used more extensively as it was designed to cover the entire Marine Engineering syllabus, from the entry-level students (Engineering Cadets) through to exit level students (Chief Engineering Officer candidates). As the students involved with the SMA study were more experienced in comparison to those partaking in the CPUT DMS study, the SMA students had the capability and industry knowledge to enable them to construct the skeletal maps amongst themselves. Once finalised, these maps were shown among the group for review and presented. At the CPUT DMS, the lesser experience levels among the population sample necessitated that the skeletal maps became very rigid and structured, with the students being given far less freedom in the population of the (blank) maps. This was configured to ensure that the lesser-experienced candidates do not stray from the task at hand.

At the SMA, the students worked in groups of two to share fixed classroom workstations for the duration of the conversion course, whilst at the CPUT DMS, the lack of institutional infrastructure necessitated the students to provide their own hardware, and use this hardware individually. As a result of this, and due to the high cost on data transmission in South Africa, it required the transfer of files via email through the purpose designed importing and exporting functionality embedded in the software. The students at the CPUT DMS were required to work with the information that was provided to them, and were required to submit assignments over weekends from within the CmapTools program for review by the lecturer. In this way, the CMapTools platform was used after hours, external to the institution (CPUT).

At the CPUT DMS, students who so wished could stay away from class as they received the same information as those that attended the classes, minus the verbal explanations received from the lecturer. Additionally, the lack of infrastructure and the use of CmapTools as a platform for covering an externally moderated examinable syllabus resulted in written assessments being done the traditional manner; away from the computer as opposed to online (as was the case at the SMA).

At the CPUT DMS, the lecturer provided the course material in lecture format and PowerPoint slides, under the designed path as laid out within the CmapTools program. Each lecture reverted back to the concept maps at each new topic to provide clarity of where the students were within the course material. The students were able to follow the lectures at their own pace through their own computer's CmapTools program, accessing the various sources of information that was provided to them in order to make the lectures meaningful to themselves. The reason for continually reverting back to the primary concept map at each new topic was again to prevent the students from 'wandering off' topic. This need for focus may not have been a requirement at the SMA, where the more experienced students would likely have been more academically disciplined and focused.

To implement this study, significant classroom changes were required to make maximum use of the limited resources at the disposal of the class.

6.7 Classroom conversion for the introduction of a computer-based model of education

The classroom conversion for the introduction of the digital Marine Engineering syllabi at the CPUT DMS was intended to accommodate the unique environment found within a developing country (most notably the limited computer hardware accessibility and the internet availability).

To implement the first phase of classroom study (based on feedback received from the initial round of surveys), a one-on-one CBT platform was laid out where each student desk was wired up to power their laptops whilst they were at their desk. A large flat screen monitor was procured and was hard-wired to the lecturer's laptop to run the CmapTools software (class display). A second laptop was connected to a separate projector screen for displaying the PowerPoint presentations (that were built around the configured concept maps). Each student loaded the software that was projected on the display monitor individually on their own computers, with email file-sharing correspondence between the lecturer and the students being responsible for keeping the various syllabus elements the same on every machine. The email correspondence facility introduced within the CmapTools platform replaced the traditional communication network that is lacking at the CPUT DMS. Whilst the email correspondence may appear unconventional, it afforded the class with a simple method of file exchange both within a classroom environment, and when students were away at sea.

The classroom desks, tables and chairs were rotated 90 degrees from the original position to make the best use of the available space, to provide for adequate wall space for the various multimedia elements that were required, and to take the student focus away from the door towards the media display units.


Figure 23: Photograph - Classroom before study (left) and during (right)

Classroom and CBT limitations experience with the 2nd Phase of the study

The second phase of this study posed somewhat of a challenge due to the fact that many of the students within the S3 group stemmed from rural communities, and as such, did not have the means for acquiring a laptop computer, nor did they have any form of internet access after hours. To facilitate a request by SAMSA, many of the junior level students (without prior sea-time) from the semester before (S2 level), were accommodated as part of the S3 class as a result of the dismal cadet placement ratio that exists within the South African shipping industry. Rather than having these students sitting at home until cadet placement became available, a decision was taken to allow them to progress through to S4 without having accrued any form of sea-time whatsoever. Whilst study without practical experience is often normal at university level, in terms of Marine Engineering, it places tremendous strain on both the part of the lecturer and the student to compensate for the lack of exposure to systems being learned about in class. The students in the S3 class (Second Engineering Officers) accounted for 60% of the student enrollment at the senior student level.

As a result of accommodating this request, the tuition methods used adopted a dual approach for this phase, with those students having laptops using the system as described for the S4 syllabus (in the first phase of the study), and those students without laptop computers being required to compile the maps and assignments on paper format and hand them in. The blank skeletal maps developed for the students with classroom computer access were printed out and bound for those students without classroom computer access. Use was made by these students of the campus library and campus computer room after class-hours to access the emailed files, and for the necessary correspondence with the lecturer as was required.

Even though these students were exposed to the concept-mapping program whilst in the class, for them it was a passive rather than active experience, with the only participation in class being through the compiling of the blank skeletal maps in paper format. The obvious drawback of this system stems from the fact that the CmapTools platform as designed for this CBT model of education at the CPUT DMS, required each student to individually customise their programs in a manner that made the learning meaningful to them.

The majority of these students were however not suited academically for study at this level and withdrew from the course after poor assessment results were obtained. These mitigating circumstances are detailed in the data collection and analysis section pertinent to this particular phase of the study.

6.8 1st Stage development: Computer use only – Scaffold learning approach

The development of the CMapTools syllabi was compiled in line with the IMO course guidelines adopted for use by SAMSA (IMO model courses for Marine Engineering Education). The existing subject and course codes used by the CPUT DMS were retained, and populated according to the mandated course codes as laid out by SAMSA. The new digital syllabus replaced the paper-based syllabus that had been used previously. This digital syllabus made use of the written material in digital format, and incorporated many visual complementary aids in order to make the text component as meaningful as possible to the students. It was important that the design and look of the CBT program that was developed follow the recommendations raised by Mayer & Moreno (2002) which was that a digital models should be as uncluttered in appearance as possible, whilst having the feel and convenience of a website operation. To do this, the material that was compiled to meet the IMO and SAMSA code requirements was unpacked into the four subject offerings in daily and weekly segments, and was sized accordingly within each category to fit in with the time frames available. In this manner, the user-friendliness of the program could be ensured, whilst not becoming intimidating to unfamiliar users (Muirhead, 2002).

Once the software had been installed, and the course files transferred to the students computers, the activation of the program started at the home screen, where the students could select the subject of their choice. Clicking on any relevant link would direct them to the subject homepage, where further selection would direct them to the relevant subject page.

Figure 24: Homepage (left) and Subject Content page (right) image

Each and every subject chapter, whether it was covering ship handling, refrigeration or power transmission, had been designed to fit on a single page, with all relevant information pertinent to that chapter being accessible from that particular single source. This feature helped to form boundaries of the knowledge requirements for the students, so that the volume of work required did not appear excessive. Retrieval of information from the chapter page was done through the student expanding the linkages, and once complete, the student could close the link until the following time the information was required. This ‘mountain-top’ view followed the design elements as described by Chatterjea & Nakazawa (2008), as being a feature that enables the students to gain a perspective of the bigger picture with regards to what they are studying, before allowing them to zoom in to retrieve more detail.

The timeframes for the course fitted within the 10,5 hours per week contact time that was available. The course diary depicted the guided planner that was available for the students to follow which lecture topics would be covered on which days, and for viewing deadlines for assignment and assessment submissions.

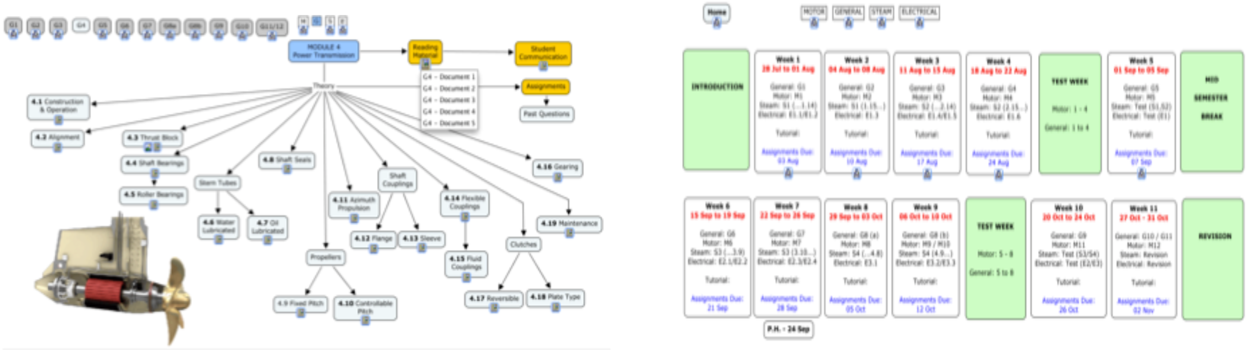


Figure 25: Sample Chapter (left) and Course Planner (right) image

It was the intention at the design phase that the material within each segment be grouped so as to represent a logical flow if information from once source to the next. Furthermore, similar sources were grouped together under common umbrellas to represent how different types of equipment are able to serve similar purposes, and to represent each particular item with each common subject theme.

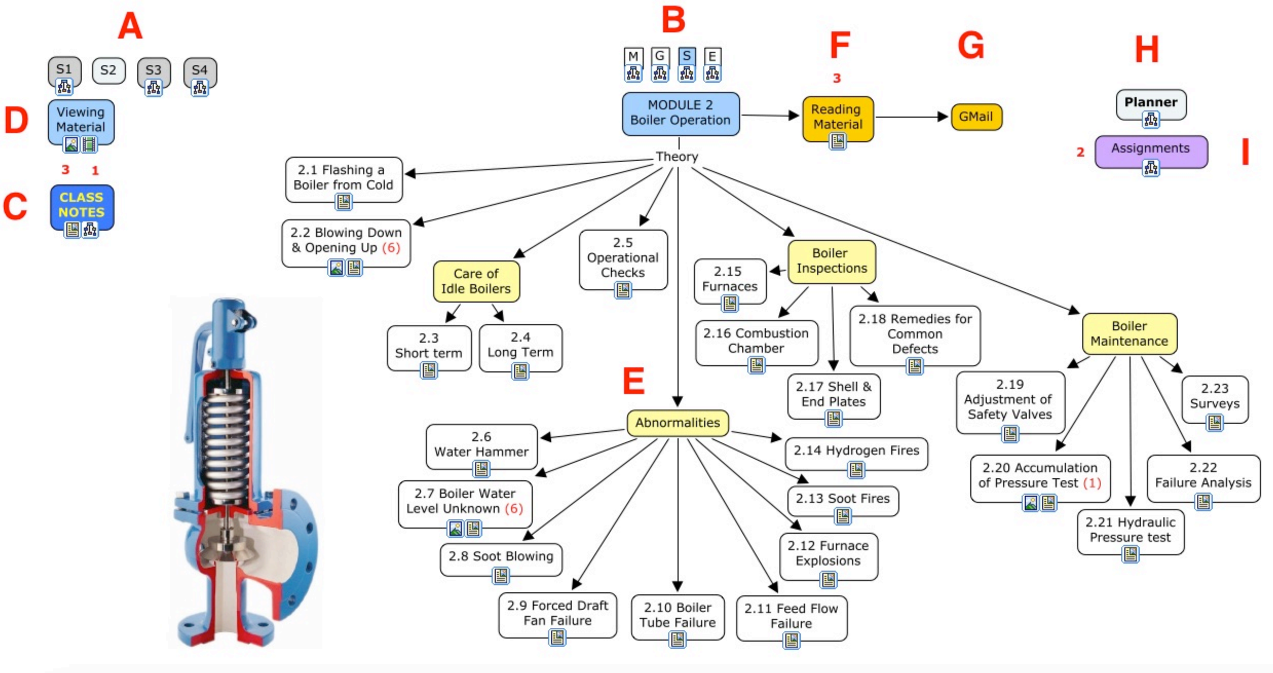


Figure 26: Developed CBT model system design elements image

The design of each individual map within the syllabus contained the following key design elements:

A - These links allow the student to navigate to the different chapters within the particular subject being covered.

B - These links allow the student to navigate to the different subjects within the syllabus. This is beneficial at times for allowing the students to view commonalities between systems and components within different subjects.

C - In addition to all of the material being spread over each node of the map, this function allows for the students to access all of the information from a single source area should they wish to do so.

D - This particular function allows for the students to submit items of interest for the class to view. Within this area, blank 'parking spaces' have been created. Once a student submits any files or media content to the lecturer, if suitable, the lecturer can email the contents to each student to import into their program. In this way the course can remain fluid and the course content can grow and remain relevant to the students. Once received by the students, the links become available the next time they log into the system. The numbers alongside the block indicate the number of files that occupy the blank parking bays.

E - This section of the map provides an example of how similar topics can be grouped under a common theme.

F - This link allows for additions to the course as deemed necessary by the lecturer during the course that the classes are run. In a similar manner to the student-posting portal, again blank 'parking bays' have been allocated, which are replaced whenever the lecturer exports a file to the students for importing into their own system. The numbers alongside the block indicate the number of files that occupy the blank parking bays.

G - This link is optional for those students who wish to use Gmail. Clicking on the link (if activated) will open up their Gmail browser for the importing and exporting of files via email. Alternatively, the students may wish to make use of any external email program they are familiar with, in which case the link would not be activated.

H - This link open the course planner (or course diary) that will keep the students informed of lectures and submission dates.

I - This link contains the blank skeletal assignment maps that the students are required to complete at the end of each days lectures. Once complete these are exported as PDF attachments and emailed to the lecturer for review and/or assessment.

Key Course Design Elements

Whilst the experience levels at the junior student level are minimal, at the senior student level, many were able to positively affect the group dynamics through their own experiences gained from within certain specialised sectors of the shipping industry. An example of this is how the students who had gas carrier or tanker experience were able to share specialisation with others in the class, who were largely unfamiliar with the hazards associated with work onboard these vessels. Through the input received by these students, and as a result of the fluidity of the concept-mapping platform, the course material and mapping constructs were able to evolve in nature; more so than would be the case with the other LMS/CBT options reviewed. A further benefit of this versatility includes the ability to keep the content material up to date with the latest industry standards and shipboard practices. In a similar manner, any input received from the students via external research that had been conducted (to complete the assignments) were reviewed within the class, after which it was added to the course content material to further build the syllabi going forward.

The first phase of the study ran from July 2014 to December 2014 for the Chief Engineering Officers class (S4), with the results from the digital syllabus being compared to that of the paper-based syllabus used in the same period in 2013. To maintain parity between the two semesters as far as possible, the exact same tests were given to each group for comparison. The same could obviously not be done with the final examination assessments, however the bias has been reduced as far as possible through the use of the external moderation process with both the examination content, and the marking of the students' examination scripts.

The CBT design to test the effectiveness of the scaffold learning methods used in a maritime setting, focused on two key areas:

(i) The layout was constructed so that all the information relevant to a particular section of the syllabus was accessible from a single page. This provided the benefits of setting definitive boundaries in terms of material content the students were required to know, and to expedite information retrieval from within the system. The graphics interface placed imagery and animations alongside the text to illustrate certain key concepts.

    Having the information resident on the each of the student's computers also served to foster course engagement, as the students were required to actively participate in the learning process. After class review of the course material was possible where the students were required to review the course material and the days learning after hours, and submit through daily assignments based on the days work.

(ii) At the end of every lecture, the students were required to complete a series of blank skeletal map assignments for submission as required by the lecturer, which was usually for Monday morning. These expert skeletal maps were completed by the students through knowledge gained from the course material, or via external research that was conducted on the topic. These concept map assignments took on various forms, as was best dictated by the material under review, and what was deemed to be the best learning process to assist with the understanding. Various forms of skeletal maps were promulgated for the initial study, and these include the following types:

- Research based maps: These skeletal maps required the students to reference textbooks, e-mailed handouts or other forms of course material in order to compile the blank skeletal concept maps to reflect their own understanding. This was intended to get the students used to condensing large volumes of text into shorter phrases, and thus make the cognitive load of the material less. These maps could be retained for later study purposes, as they had the ability to present certain concepts graphically in a summarized format.

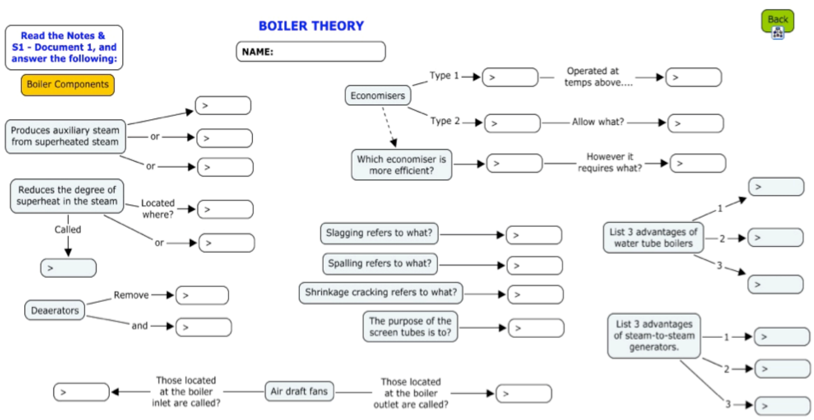
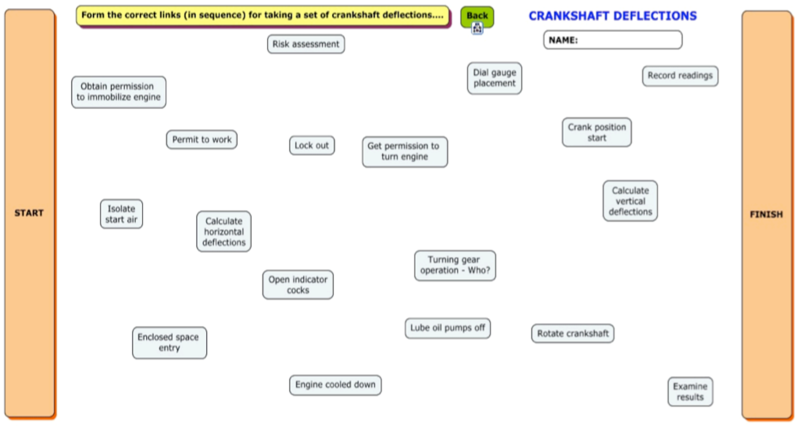


Figure 27: Example of Scaffold Assignment Skeletal Map (Boilers) image

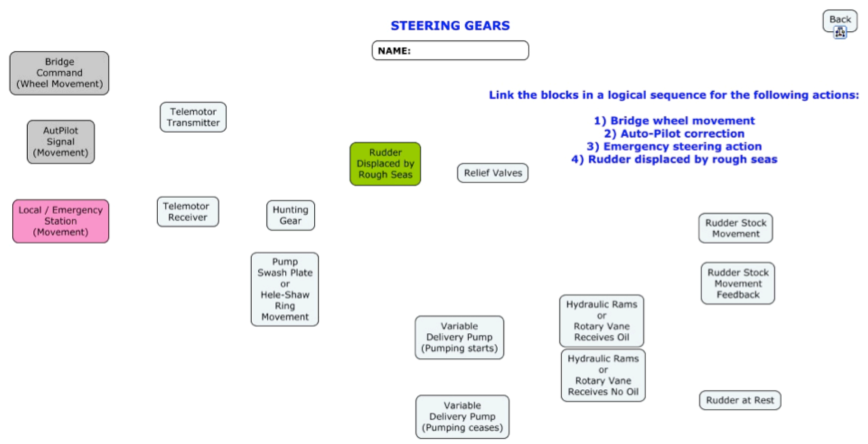
- Procedural based maps: These maps are formulated and provided in block formation without the necessary linkages between the relevant concepts drawn in. The required missing linkages form the procedural steps required in order to complete certain tasks from point “A” to point “B”. The students were required to start at one stage of the process and form the constructs to progress to the final stage of the intended procedure, and in order to complete these maps, the retrieval and use of information for the completion of the tasks in a logical sequence was required.

It is often required that the students describe onboard procedural tasks (both in written format (for assessment purposes) and when undergoing certificate of competency oral examinations. It was the intention to get the students used to the steps involved regarding both the maintenance tasks, as well as the safety aspects that each of the various tasks entail. In the example that follows, the students were asked to sort the steps in a logical step-by-step format for taking a set of engine crankshaft deflections, (by forming the linkages themselves), to include the safety considerations required to carry out the task.



<u>Figure 28: Example of Procedure Based Assignment (Maintenance Process) image</u>

- <u>Sequential based maps</u>: This design takes a similar form to that which is described in the preceding example, however instead to the linkages representing procedural steps, they form sequential links in the chain of operations. This process helps with the understanding of how a particular chain of events is dependent upon certain variables, or prior conditions being met. These maps were designed to that the students could demonstrate their understanding of how certain critical systems work onboard. The example provided is the sequence of equipment related events for different scenarios pertinent to a ships steering system. In the example that follows, the students were required to show the concepts for the signal transmission (in a logical format) for (a) a movement of the bridge wheel, (b) an auto-pilot correction signal, (c) an emergency steering operation and (d) when the rudder is displaced by rough seas.



<u>Figure 29: Example of Sequence Based Assignment (Steering Gears) image</u>

- <u>Cause and correction maps</u>: This design of expert skeletal map was intended to illustrate a chain of events that can be the cause of a certain condition forming, which then leads into a second map section representing the correction or avoidance process to negate the causation. These maps were compiled out of a need to understand what steps cause certain engineering related conditions to arise, and emanating from that, how these conditions can either be avoided or addressed (corrected).

  The map below illustrates an example of a map detailing the process of corrosion of a ships hull, and then in order to prevent this from happening, the process of cathodic protection. Done in the form of blank skeletal maps, the students are able to see events leading up to a problem (or potential problem), and a corrective solution to counteract these.

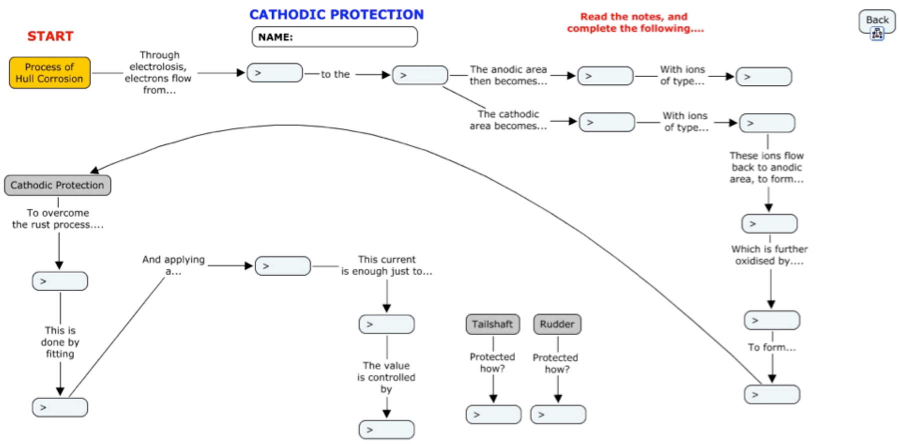


Figure 30: Example of Cause & Correction Based Assignment (Cathodic Protection) image

- Shipboard system maps – The final classification of map for the purpose of this particular phase of the study had been configured in an attempt to develop the understanding of ship specific systems. Sketches have been used as the background for these assignment maps, and the scaffold process was superimposed over the relevant sketch. The students were then required to complete the labeling of the sketches, and to illustrate certain processes and key components that can be described with the aid of the sketch.

  An example of a ship specific concept map is given in the example that follows. In this example, the students were required to represent what would happen in the event of an electrical blackout occurring onboard a ship (i.e. to describe what certain functions the key components within the sketch would perform in the event of a blackout occurring onboard).

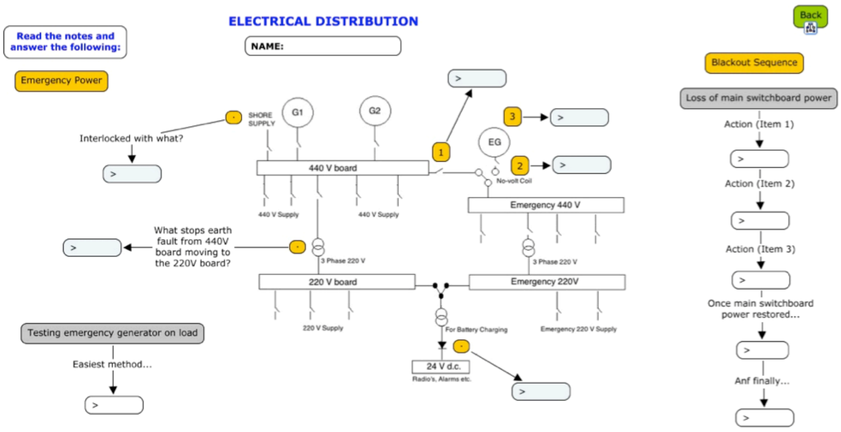


Figure 31: Example of Sketch Assisted Assignment (Electrical Blackout) image

At the end of each week, the students were required to submit on average six concept map assignments (in various formats) through the export process for review, and these were assessed and graded accordingly. In order to further eliminate any bias, these marks were graded as assessment three, and were thus not included as a marked assessment for the purposes of this study (although it remained a requirement for examination entry purposes of the institution). In this way, only the written formal assessments were used for analysis, as well as the marks obtained in the written final examinations. This was important so that a like-for-like comparison between the relevant phases of the study could be maintained.

A sum total of sixty assignments were compiled for completion over the duration of the thirteen weeks that the course was conducted before the examination phase of the semester commenced. Discounting the test weeks, this quantity for submission averaged six assignments per week, however this was altered slightly to cater for certain chapters being larger of smaller in comparison to the rest. The students were asked to submit the weekly assignments by Sunday evening each week at the latest, however certain flexibility was afforded for early submissions, as this was seen as a positive in the students reading the material beforehand, and preparing for the work to follow. For those students who could only obtain internet access upon return to the CPUT DMS on Monday morning, grace was afforded them to submit the emails on Monday mornings using CPUT's internal servers. In general, the students preferred to compile the assignments in the week that the work was covered in the class, as in this way, many felt that the assignments were more easily viewed against the backdrop of the course material that was discussed that particular day.

Among this senior group, preference was given to the purely scaffold assignments (skeletal - example: figure 27), as these maps were viewed as a concise knowledge organisation tool for study purposes. The benefits of this type of assignment include their ability to place large amounts of information into ‘bullet’ points that form a graphical portrait (overview). Similarly the sketch-assisted assignments (example: figure 31) were appreciated for their ability to place key knowledge among the backdrop of a sketch of a shipboard system. The procedure-based (example: figure 28) and sequence-based (example: figure 29) assignments were viewed as being less demanding, due to the fact that this group had a much better understanding of this sector of the job, as many were in already in management positions onboard a ship (i.e. Second Engineering Officers).

An observation made over the course of this phase of the study was that the majority of the students preferred to print the digital course notes out, and utilise the paper format notes to highlight key points within the text as the lectures progressed. Additionally, towards the end of the first trial semester, the textbook that had been written to comply with the SAMSA code requirements was published for use as the prescribed textbook at both CPUT and DUT. For these reasons, the second phase of the study was compiled in a manner that could make use of printed literature, with the CBT program aiding in turning the printed literature into meaningful knowledge through the graphic and additional file components. This thought process fell in line with Chatterjea and Nakazawa’s (2008) findings at the SMA, that a graphical concept mapping course has the ability of making knowledge meaningful.

With these changes being made to the CMapTools program, the second phase of the study was ready for trialing in January 2015 at the S3 level.

6.9 2nd Stage development: Computer aided approach – CBT use to supplement paper-based text

The second phase of this study that was trialed from January to July 2015 bought some challenges that were part and parcel of the environment in which South African

MET institutions operate within. As a result of the inability of the South African shipping industry to meet the demands of the engineering cadet placement onboard South African vessels, the vast majority of students at the junior student level from 2014 (S2) could not secure placement onboard ships as engineering cadets after the completion of their initial studies. At the request of both SAMSA and SAMTRA, many of these students were afforded the opportunity to continue their studies through to the senior student levels of S3/S4, rather than wait around for news of possible placement onboard a ship, and becoming unemployed. However, as it was found through the initial round of surveys conducted at this level, some of these students did not possess laptop computers, which made a purely computer-based syllabus not a viable option for this phase anyway.

Many of these students that required accommodating in this manner, stem from rural areas within South Africa. These students would have grown up without computers, in the manner that many of the more advantaged students did. Cognizance of Wood and Bandura’s (1989) findings that students without prior computer experience may achieve poorer academic outcomes in a course reliant on CBT was taken into account for this phase of the study, with the intention being that the blending of course delivery methods could provide a system that students from all backgrounds could feel comfortable with.

Fortunately, the blended learning design elements that were introduced for this phase of the study were suited to deal with these constraints that were encountered. As the written information was delivered in print format as opposed to digitally, and the CBT model introduced to supplement the print format, the format was well suited to aid the understanding of shipboard systems and components for these unfamiliar students. Those students without laptop computers were required to follow the class presentations, sit alongside students who had laptop computers, and to utilise the campus computer room or library computers to access information. For the completion of the blank skeletal maps, each student who had no access to computers after hours was provided with a bound book of blank skeletal maps for completion in paper format, which was handed into the lecturer for assessment.

The textbook that was introduced to supplement the CMapTools program had been developed over a number of years to accommodate the changing code contents as introduced by SAMSA when the Manila 2010 amendments came into force. At the request of the SAMSA examiners shortly after the Manila 2010 amendments necessitated changes to the syllabi, work began on formulating one textbook that could be used (a) from Officer of the Watch to Chief Engineer in South Africa and (b) be introduced at both CPUT and DUT as the syllabus textbook so that both institutions work from the same material. The introduction of the textbook resulted in only minor changes being made to the CMapTools program as the software was configured in line with the way the syllabi were laid out. Originally written as individual texts to cover the General Engineering Knowledge subject, a textbook was published by Lambert (2014) entitled 'Marine Engineering Theory: Volume 1 – General', in the same logical flow format offered by the CmapTools program. It was the intention to offer the students material in which they could highlight important text, make notes in etc. in a manner that is easier to do on paper than in digital format.

In addition to the blending of course content between print and computer-based media, another form of blended learning was practiced during this phase of the study to accommodate two senior students who were serving the industry at sea. The delivery method for these students (who were only able to attend class during their leave periods) was conducted along the lines of classroom delivery when in attendance, and distance learning through the concept-mapping platform when at sea. It is through this method of syllabus delivery that senior distance learning students could be accommodated for the first time in a maritime course of this nature in South Africa. The communication channels that were designed into the software and tested in the first phase of the study (in a classroom environment) was taken offshore to aid those students in the workplace to further their studies without necessitating the taking of unpaid leave or resignation from their companies to attend class.

The CmapTools (for this part of the study) served as supplementary media to aid the comprehension of the written theory, through a process of placing the text into shipboard perspective with images, photographs, animations video clips etc. to elaborate of n the student sketches within the written text. Students would attend class and refer between the textbook and the CmapTools program as they were required to do so. At the end of each chapter, the students were again required to compile and submit the blank skeletal assignments based on the days work in class.

The design of the marriage between the written textbook and the CMapTools program as used for this study contained the following key elements:

A - The textbook numbering was aligned with the CMapTools numbering system, in such a way that section 3.2 for example in the textbook, referenced the second node on the third map of the concept map for that particular chapter. This made searching and referencing information within the syllabi user friendly to expedite.

B - The sketches that the students were required to replicate (both for CPUT assessment purposes and SAMSA CoC assessment purposes were laid out in the textbook, as well as on the CMapTools program. The required replicable sketches in the CMapTools program were clearly marked to reduce any ambiguity on the part of the student as to which sketches are required. Elaboration on the written text and student sketches provided was done through the CMapTools program as indicated by section C.

C - Numerous forms of media were made available under each relevant section within the textbook in order to place the texts and sketches in a shipboard context. In the example provided, the text and student sketch covers water lubricated stern tubes, and the respective images show alternative sketches, photographs, animated graphic and video clips as applicable.

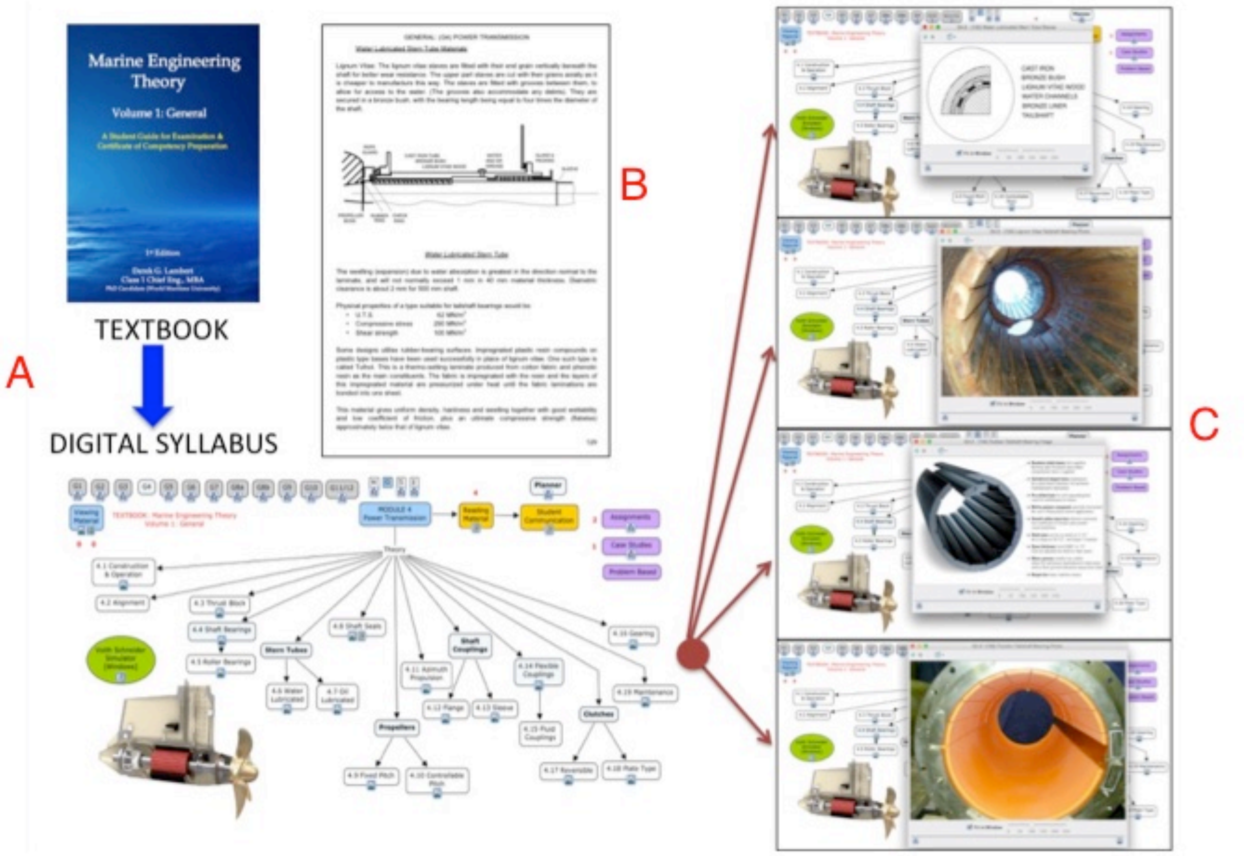


Figure 32: Computer use in conjunction with written literature image

Whilst the visual media that was introduced in the first two phases of this study were able to aid in compensating for those students who were lacking in practical experience, there was a need to get the students more involved and familiarized with how the material that is viewed in the classroom corresponds to that equipment found onboard ships. This was the motivation behind introducing the prominent learning methods that were trialed in the third and final phase of the study.

6.10 3rd Stage development: Learning method introduction – Testing the effectiveness of the chosen learning methods used

The third phase of the study that commenced at the start of the second semester in 2015 involved a total of 31 Chief Engineering Officer candidates (the S4 group). This phase saw the introduction of two prominent learning methods, namely case-based learning, and group based learning. As a result of the confounding variables that exist among the different student groups, and to simplify the assessment criteria, the learning methods introduced were not to be assessed individually within this study, but rather as a collective process working in unison with each other.

Case-based learning was chosen as a learning method because it is one that is well adept to the learning of onboard maintenance procedures and workplace related awareness enhancement scenarios. This component is beneficial within an industry that is lacking in maritime experience, as is the case with the many of the Southern African students, despite them being at a fairly high level academically. On-the-job awareness enhancement is also a priority of the SAMSA examiners, from a CoC oral examination perspective[63]. The CBL aspect was designed to include two distinct types of cases, (a) the first involving the process of learning from prior events and sample procedures, and (b) the second from incorporating elements within the course that many of the seafarers were physically familiar with (vessel specific).

The assignments for this phase had been configured to better develop an understanding of certain key engineering maintenance routines and best practice scenarios, as well as towards dealing with operational problems that the students may experience when onboard the vessel. Building on from the previously configured procedural maps, these case-based skeletal map assignments were aimed towards hands-on maintenance and familiarisation techniques, and on-the-job awareness development for when an emergency situation arises.

At the conclusion of each learning activity, the students were provided with a case study that was closely related to the days lecture. Here the students would be required to read and discuss the case study in their groups, and to debate the happenings, and where possible, provide corrective or avoidance solutions to the cases. The blank skeletal maps provided to the students were populated with information derived from each of the cases. The favoured format for these skeletal assignments was primarily in the form of the procedure-map format and the sequence-map format used previously. The layout in many cases was designed to use the theoretical text and examples provided in the cases in a ‘practical’ or ‘job focused’ format.

[63] As per feedback received from the SAMSA examiners during the 2013 SAMSA/CPUT syllabus review meeting held at CPUT.

Engine specific maintenance manuals were also introduced as part of the course content in an attempt to provide a practical source of reference material for the compilation of the case-based assignment maps. These practical information sources were used in conjunction with the existing course material and textbooks. A slightly greater degree of freedom was afforded the students as far as the case-based activities were concerned, as the idea was to make extensive use of group-work in order to foster dialogue and promote a discussion/debate among the students in order to clarify the particular case information. With regards to the formulation of the student groups, the class was allowed to divide themselves into groups in which they felt the most comfortable. This was generally done according to those who shared commonality in terms of language and culture, so that they could aid each other to better clarify any language related ambiguities that existed.

Certain challenges were faced with regards to equal student input and task accountability, as the experience level differences within the groups naturally resulted in the more experienced students assuming a more prominent role within the group. However, one of the benefits of this was that the lesser-experienced students were able to learn from their more experienced fellow students as part of the team, in much the same way that learning takes place in a practical environment onboard a ship. In many instances, observations were made of the group discussions resembling an informal mentorship process.

The two forms of case-based learning that are described in the section that follows, incorporated both activity focused case elements and familiarisation focused case elements.

Case-based learning activity design elements

The CBL activity design elements were primarily aimed at addressing the lack of shipboard experience among the lesser-experienced students, and as a result, may have benefitted those students more than their more experienced counterparts. Due to the very limited size of the South African maritime industry, many of the students are lacking in practical knowledge of how certain key shipboard tasks are to be carried out. This deficiency has certain safety repercussions largely as a result of the students being unfamiliar with what hazards exist in certain applications, and are thus unable to identify how these hazards can be managed or prevented altogether.

The majority of the CBL assignments were drawn from actual details of components that had failed, or from onboard events that have relevance to the theoretical work covered within the classroom. The students were then tasked with viewing the case study assignment material within the context of the preceding lectures. The assignments used for this form of case-based learning adopted the models used by Aamodt & Plaza (1994), namely (i) exemplar (classification), (ii) instance (possible solutions), (iii) case based (events) and (iv) analogy based (information retrieval).

- Exemplar assignments. An example of en exemplar form of case-based assignment is shown. This example requires the students to view the case material, and then to classify the failed component into various categories in terms of the failure itself. This failure analysis would include the test methods used, the reason for the failure etc.

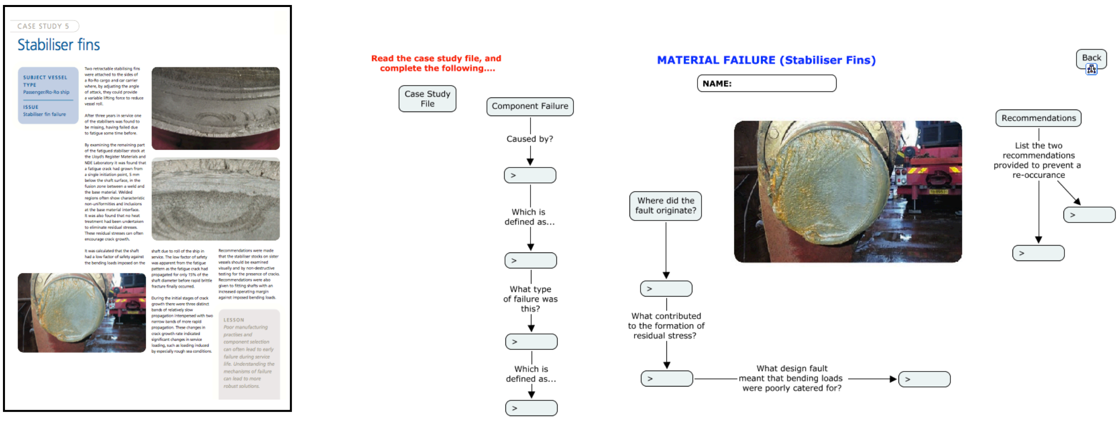


Figure 33: Example of an Exemplar Case-based Assignment Map & PDF (Material failure) image

- Instance assignments. These skeletal assignment maps required the students to read about certain scenarios and failures, and to provide possible solutions or methods of preventing a future re-occurrence of the event. Whilst this process appears similar to the skeletal maps assignment type that follows, these cases refer to the vessel operations aspect of the task (the human element).

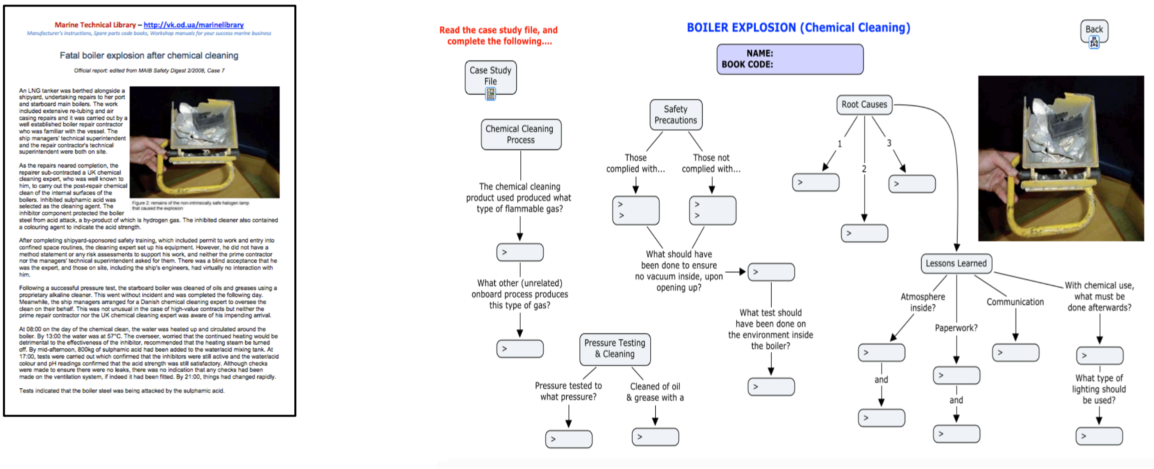


Figure 34: Example of an Instance Case-based Assignment Map & PDF (Boiler explosion) image

- Case-based. These maps detail certain events that have happened, and require the students to populate the maps with solutions and preventative measures for future reoccurrence. These cases refer more specifically to machinery related failures as opposed to the human element shortcomings mentioned in the previous example.

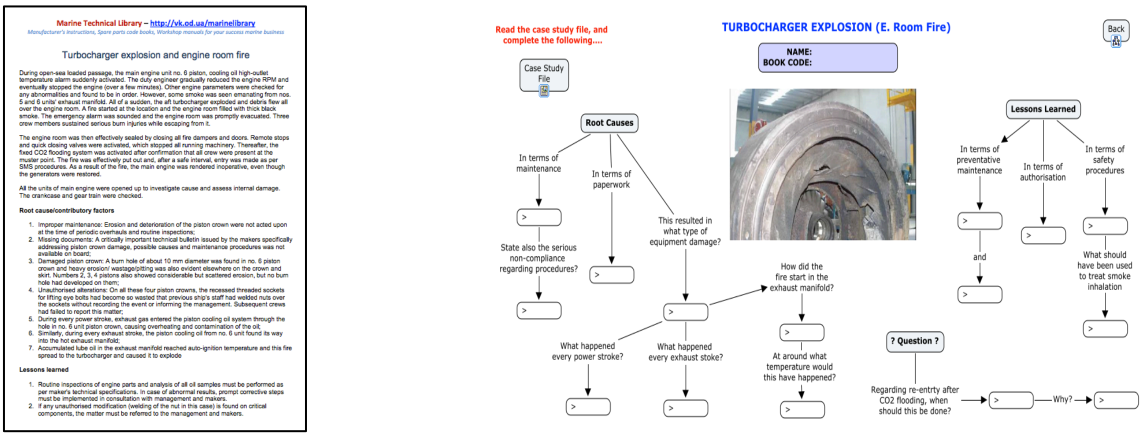


Figure 35: Example of a Case-based Assignment (Events) Map & PDF (Turbocharger failure) image

- Analogy-based. This form of skeletal assignment requires the student to refer to multiple sources of information in order to complete the assignment. This process aids the students in identifying the similarities that exist between the various elements of the syllabus, and between the different subjects within the syllabus.

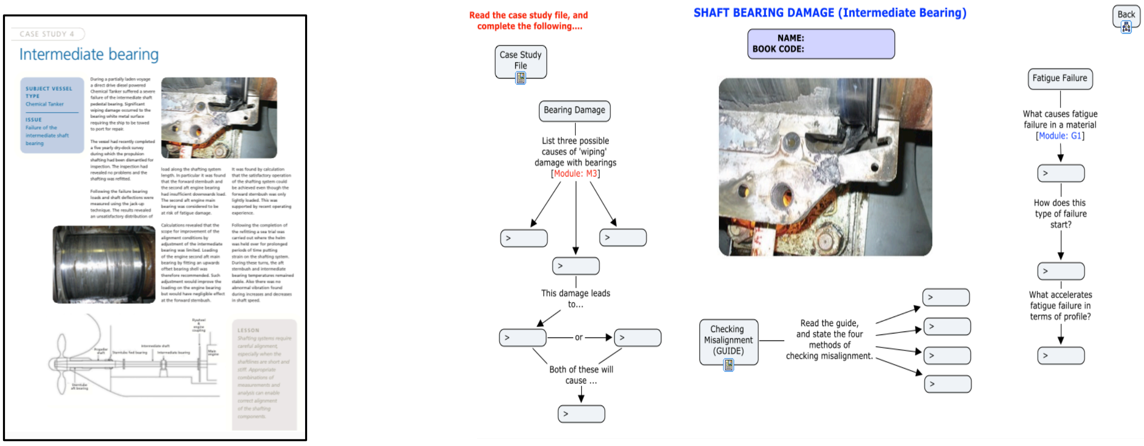


Figure 36: Example of an Analogy Case-based Assignment Map & PDF (Shaft bearing failure) image

Case-based learning familiarisation design elements

As a result of the South African Maritime industry being the size it is, the majority of the students who have seagoing experience are employed by one of four companies. These companies include (a) Unicorn shipping (product carriers), (b) Safmarine/Maersk (container vessels and bulk carriers), (c) Smit Amandla Marine (offshore support, salvage and Antarctic supply vessel operator) and (d) The National Ports Authority (harbour services).

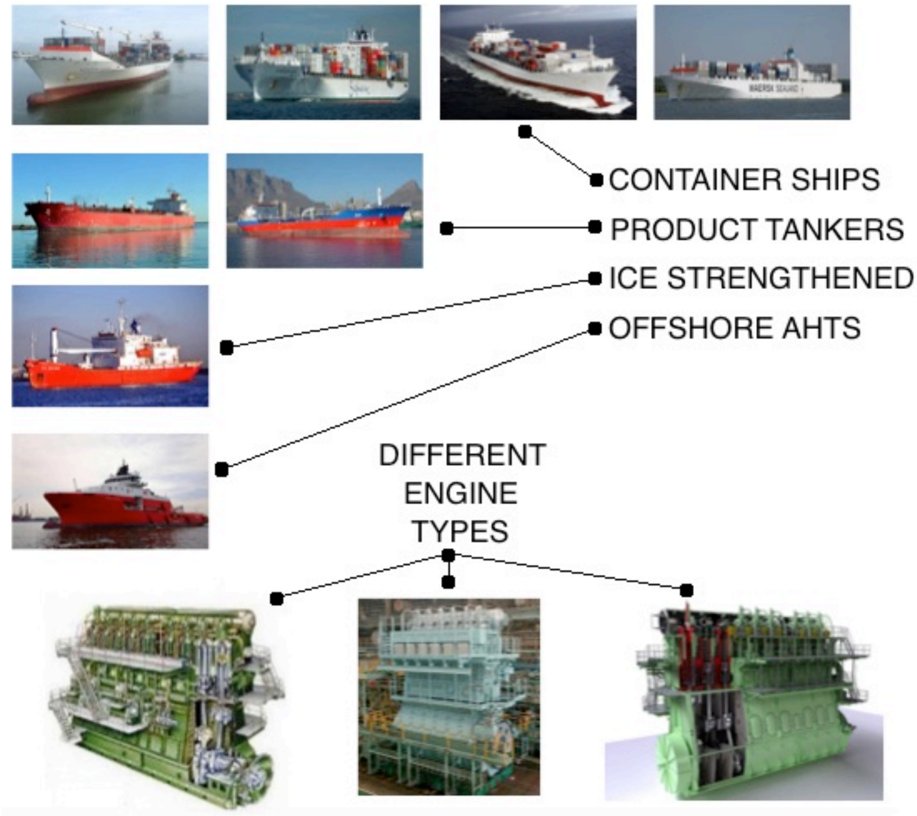


Figure 37: South African Vessel and Equipment types used for compiling the Case-based learning component image

To provide more of a familiarisation aspect to the course, many of the images that were used to initially compile the CMapTools program were replaced with images from the vessels on which the students had previously sailed. This material came from two main sources. The first source was from photographs taken of the relevant vessels and associated equipment when they docked in the port of Cape Town. The second method used was from media files that were provided by the students themselves.

As the lectures and CBL assignment activities progressed, the students were able to view images from South African ships, and in many cases, equipment they have previously worked on as opposed to textbook and internet sourced imagery. Additionally, three main types of slow speed engines are prominent onboard the types of vessels on which the students serve. These engine types include (a) loop scavenged engines (ported), (b) uniflow scavenged engines (incorporating an exhaust valve) and (c) a camshaft-less engine (common rail). Examples were used of each of these engine types to enhance the familiarisation aspect.

Additionally, certain of the students had many photographs that had been taken of engine maintenance tasks, but as a result of them being possibly at a junior level, were not totally clear of what it is they were looking at or indeed working on at the time the photographs were taken. The case-based additions to the CMapTools program is described in the diagram that follows (numbered 'A'). Once the students expand the selection for the relevant engine type, they are presented with images of how these key tasks and maintenance procedures have been carried out either by their fellow students or by other South African seafarers in the past.

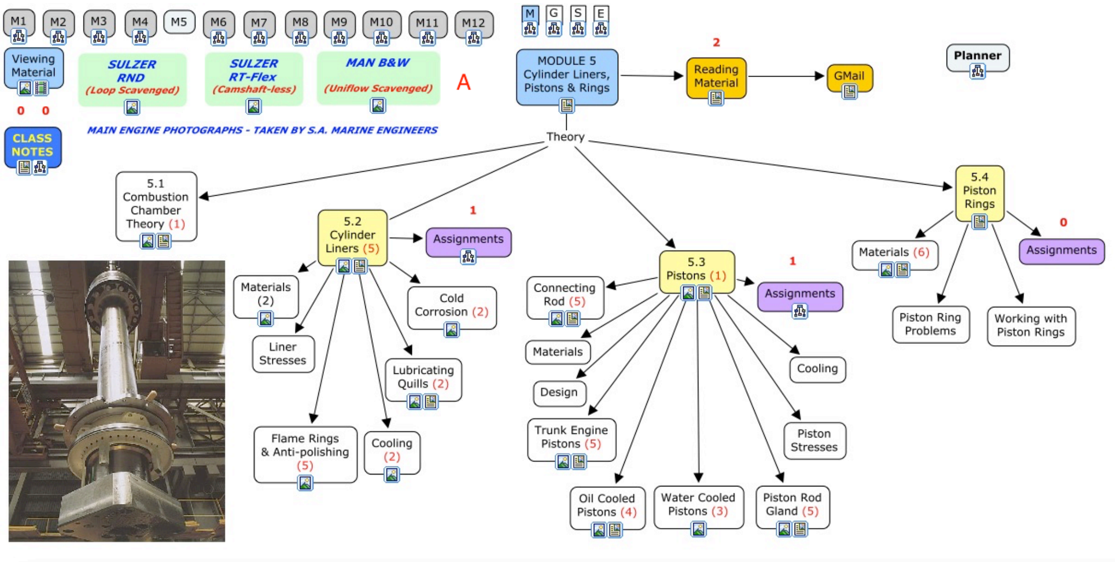


Figure 38: Case-based learning component: Engine procedures familiarisation (overview) image

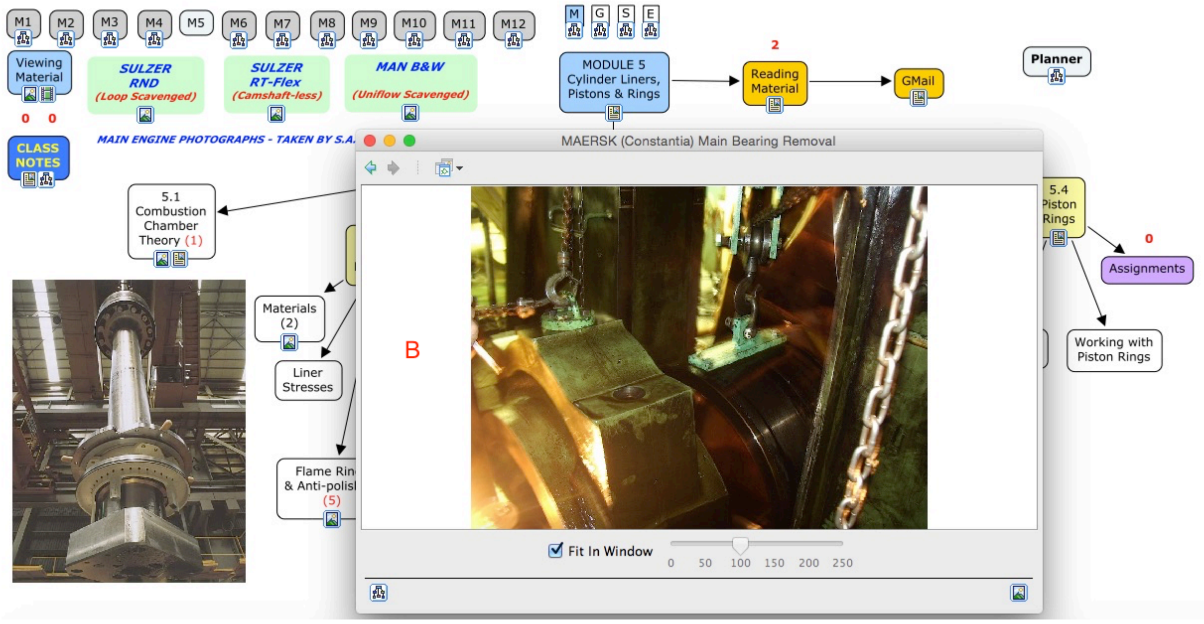


Figure 39: Case-based learning component: Engine procedures familiarisation (Expanded example: Bearing change) image

Group-based learning design elements

The language component of the survey comprised a page of text (455 words) where the students were required to highlight unfamiliar words. The findings (detailed earlier in this chapter) indicate a negative correlation to exist between English language competency and assessment outcomes.

The GBL structure afforded the students greater opportunity to clear up language related ambiguity, and to learn from each other within the confines of the classroom environment. It was thus from this approach that the results of the third and final phase of the study (collaborative learning) would be compared to the previously implemented individual focused computer based syllabus.

The GBL format used in the class was informal, with the peer interaction process taking place for the working through of the various CBL components, completing work related projects in groups (not counted for as an assessment as part of this study) and for classroom discussion time after the lectures ended.

Summary

After the initial student survey needs analysis had been conducted, and after the CBT model had been developed in line with requirements (at each phase of the study), the data analysis phase could begin. This data collection process, and the manner with which the collected data was analysed, is described in the chapter that follows.

CHAPTER 7

DATA COLLECTION & ANALYSIS

Introduction

Data was collected at each phase of the study through different methods, in order that the data results obtained could be triangulated as much as possible to reduce bias. Due to the fact that there were three distinct student groups who partook in this study, each of the research sub-questions has been answered in turn. From these findings, the outcomes would be ultimately used to answer the research question.

7.1 Data collection and data analysis methods used

The data collected over the course of this study was compared with the results from each previous semester that was conducted on the same level of study. In order to answer the research question that has been devised, (a) learning theories were selected to guide the teaching and learning process, (b) learning and thinking style choices were incorporated into the student assignment maps within the CBT design, (c) learning methods were implemented with which to implement the selected learning theories or chosen styles, (d) Blooms taxonomy was used in order to set certain student assessments, (e) various analytical methods have been devised in order to assess the outcomes at each phase and (f) as a final countermeasure, a peer-assessment review of the examination standard was conducted using data obtained from professional peers within the maritime industry.

<u>Measuring student outcomes</u>

Methods that can be used to measure student learning each have limitations and biases, with no particular method being regarded as completely error free. The best practice in terms of education research is to triangulate the data received. Assessment of data can be strengthened through the use of both direct and indirect measures, as the two forms together can present a more accurate picture of the learning outcomes.

Direct assessment methods include activities such as written subject tests and completed assignments (concept maps), which can be systematically reviewed to ascertain evidence of learning. Student grades can also be an indication of learning, provided that the determination and reporting thereof do not undermine their usefulness (Breslow, 2007). Indirect measures include information that can be derived from survey data or from analysis conducted of student pass rates, and pass rates within certain categories.

For this study, the freedom that was available to other engineering disciplines at CPUT with regards to the types of assessments that they could conduct was not given to the DMS, due to the fact that all assessments are required to follow a specific format so that they can be auditable by SAMSA. For this reason, direct methods of assessing outcomes include statistical analysis of the written assessments results, and from viewing assessment criteria set specifically to the Blooms taxonomy scales. Indirect methods were used to triangulate these results through the surveyed data received at the end of each phase.

The data collected over the course of this study has been compiled using a mixed data collection method, which can be summarised according to the table that follows:

Data Collection Method	Group	Number	Total Analysed
Data Points Analysed *Quantitative*	2013 (S4)	249	1513
	2014 (S3)	239	
	2014 (S4)	235	
	2014 (S3)	490	
	2015 (S4)	300	
Primary Surveys Distributed / Received (Survey No. 1) *Quantitative, Qualitative*	Needs Assessments	74	393
	S3 Students (2014 – 2015)	125	
	S4 Students (2013 – 2015)	194	
CBT (Scaffold) Distributed / Received (Survey No. 2) *Quantitative, Qualitative*	S4 Students (2014)	12 from 28	12
CBT Computer Aided Distributed / Received (Survey No. 3) *Quantitative, Qualitative*	S3 Students (2015)	29 from 38	29
Learning Methods Distributed / Received (Survey No. 4) *Quantitative, Qualitative*	S4 Students (2015)	13 from 18	13
Institutional Interviews *Qualitative*	2013 – 2014		3
Association Interviews *Qualitative*	2013		1
Peer Review Surveys Distributed / Conducted (Chief Engineers) *Quantitative*	2016	13 from 13	13
Peer Review Interviews (SAMSA Examiners) *Quantitative*	2016	2	2

Figure 40: Table - Data collection methods used and sample frequency

An outline of the process adopted in order to test each research question, can be found as follows:

RESEARCH SUB-QUESTION 1		
By adopting a purely paper-based method of tuition as opposed to the purely computer-based method of tuition that previously existed, would there be any notable improvements in student learning outcomes among the research participants?		
LEARNING THEORIES USED		
Constructivism: [Vygotsky: Theorist] Constructionism: [Papert: Theorist]		
LEARNING METHODS SELECTED		
Scaffold learning: [Vygotsky: Theorist, Novak: Concept Mapping]		
METHODS OF ANALYSIS		
Quantitative *(Section 7.2.1)* *Sample size: 235*	(1) Statistical overview	*Means, deviation of results, skewness of results analysis between respective groups*
	(2) Experience/marks correlation	*Correlation: Experience to marks analysis*
	(3) Proficiency growth model	*Overall student pass rates analysis*
	(5) Performance Index growth model	*Pass rate analysis within different segments of student outcomes*
	(4) Simple growth model	*Analysis of outcomes by tracking the same students in respective semesters (S3-S4)*
Qualitative *(Section 7.3.2)*	Survey # 2: Scaffolding	*Analysis to determine student perceptions of scaffold learning as a learning method*

Figure 41: Table - Research sub-question 1 – Data analysis method

RESEARCH SUB-QUESTION 2		
If the CBT model were tailored to work in conjunction with existing paper-based literature in order to enhance the understandability of the texts, would there be any notable change in terms of academic outcomes among the research participants?		
LEARNING THEORY USED		
Constructivism: [Vygotsky: Theorist] Constructionism: [Papert: Theorist]		
LEARNING METHODS SELECTED		
Scaffold learning: [Vygotsky: Theorist, Novak: Concept Mapping]		
TAXONOMY USED		
Blooms revised taxonomy		
METHODS OF ANALYSIS		
Quantitative *(Section 7.3.1)* *Sample size: 490*	(1) Statistical overview	*Means, deviation of results, skewness of results analysis between respective groups*
	(2) Experience/marks correlation	*Correlation: Experience to marks analysis*
	(3) Proficiency growth model	*Overall student pass rates analysis*
	(4) Performance Index growth model	*Pass rate analysis within different segments of student outcomes*
	(5) Simple growth model	*Not applicable to the first level of management students (S3)*
	(6) Blooms Taxonomy	*Analysis to determine student understanding through assessments compiled according to a Blooms taxonomy scale*
Qualitative *(Section 7.3.2)*	Survey # 3: Scaffolding	*Analysis to determine student perceptions of scaffold learning as a learning method*

Figure 42: Table - Research sub-question 2 – Data analysis method

<table>
<tr><th colspan="3">RESEARCH SUB-QUESTION 3</th></tr>
<tr><td colspan="3">Would incorporating learning methods based on prominent learning theories, that have been specifically developed in order to address the identifiable challenges that exist, have any significant impact in terms of learning outcomes among the research participants?</td></tr>
<tr><th colspan="3">LEARNING THEORY USED</th></tr>
<tr><td colspan="3">Constructivism: [Vygotsky: Theorist] Constructionism: [Papert: Theorist]
Social learning: [Bandura: Theorist]</td></tr>
<tr><th colspan="3">THINKING & LEARNING STYLES USED</th></tr>
<tr><td colspan="3">Sternberg’s thinking style model: [Function, level, scope, leaning]
Kolb’s learning style model:
[Concrete/reflective, abstract/reflective, abstract active, concrete active]</td></tr>
<tr><th colspan="3">LEARNING METHODS SELECTED</th></tr>
<tr><td colspan="3">Scaffold learning: [Vygotsky: Theorist, Novak: Concept Mapping]
Group-based learning: [Bandura: Theorist]
Case-based learning: [Sternberg: Thinking styles, Kolb: Learning styles]</td></tr>
<tr><th colspan="3">TAXONOMY USED</th></tr>
<tr><td colspan="3">Blooms revised taxonomy</td></tr>
<tr><th colspan="3">METHODS OF ANALYSIS</th></tr>
<tr><td rowspan="6">Quantitative

(Section 7.4.1)

Sample size: 300</td><td>(1) Statistical overview</td><td>Means, deviation of results, skewness of results analysis between respective groups</td></tr>
<tr><td>(2) Experience/marks correlation</td><td>Correlation: Experience to marks analysis</td></tr>
<tr><td>(3) Proficiency growth model</td><td>Overall student pass rates analysis</td></tr>
<tr><td>(4) Performance Index growth model</td><td>Pass rate analysis within different segments of student outcomes</td></tr>
<tr><td>(5) Simple growth model</td><td>Analysis of outcomes by tracking the same students in respective semesters (S3-S4)</td></tr>
<tr><td>(6) Blooms Taxonomy</td><td>Analysis to determine student understanding through assessments compiled according to a Blooms taxonomy scale</td></tr>
<tr><td>Qualitative
(Section 7.4.2)</td><td>Survey # 3: Learning methods</td><td>Analysis to determine student perceptions of GBL & CBL as learning methods</td></tr>
<tr><th colspan="3">BIAS REDUCTION METHOD ADOPTED</th></tr>
<tr><td colspan="3">Professional peer assessment review of examination standard: Delphi-method.</td></tr>
</table>

Figure 43: Table - Research sub-question 3 – Data analysis method

A brief explanation of each of the methods of analysis follows:

(1) Mean assessment outcomes comparison vs. student experience levels

The mean results for all written assessments and examinations conducted over the course of the semester have been tabled alongside the experience ratings allocated to the students within the group as determined by the initial surveys (survey 1). This was done to place the changes noted in the mean results at each phase in context with the experience ratings of the students.

(2) Examination outcomes vs. examination difficulty rating

The core subject (General Engineering Knowledge) examinations results from each phase of the S4 group was tabled alongside the perceived difficulty rating of each examination as perceived by peers within the industry (Delphi method).

(3) Correlation measurement of assessment outcomes vs. experience

This was done after each phase was completed (marks obtained vs. experience rating) to ascertain how each sector of the population sample fared within the group, and between successive groups. This was done to provide another indicator as to the effectiveness of the methods in use for that phase.

(4) Test for statistical significance

The assessment results from each phase was subjected to a t-Test (appendix 2) to ascertain whether the differences in assessment outcomes that was noted between phases can be considered statistically significant, or whether the difference may be as a result of random sampling error.

(4) Student proficiency rates (successive semesters)

The proficiency growth model simply compares student pass rates for the assessments and examinations conducted over the course of the semester, and views these in comparison to one another. Along with these outcomes, (a) the student experience levels need to be taken into account, as does (b) the peer review assessment conducted of the General subject examination standard.

(5) Same individuals tracked through successive semesters

The final comparative indicator tracked changes that were noted between the results obtained from the same individuals doing successive semesters (S3 followed by S4). This indicator discounts the confounding variable that exists elsewhere in the study where students with different abilities are compared.

Finally, the tabled findings are viewed against a brief summary of environmental factors that may have changed within the student landscape, over the course of the eighteen months in which the data was collected.

7.2 RESEARCH SUB-QUESTION 1: Computer-based learning analysis

The S4 class of 2014 comprised the senior level students within the Marine Engineering study stream at the CPUT DMS. Data derived from this group indicated that the experience levels within this group were all at an acceptable level, with none of the students being in the position of lacking industry experience in one form or another.

In total, 28 students started the S4 course, although not all of them enrolled for all four subjects that this study covers, as certain students were returning students who had previously attended classes before but had failed certain subjects.

This phase of the study examined the impact that a change from a purely paper-based syllabus to a computer-based syllabus had on the students at this level (S4).

7.2.1 Research sub-question 1: Statistical data analysis

The first phase of this study compared the noticeable outcomes associated with the use of computers only as the syllabus delivery method, in comparison to the purely paper-based syllabus used in 2013. This computer-based scaffold learning part ran from July to November 2014, with the participants comprising those students studying towards their Chief Engineering Officer certificate of competency (S4 students).

The four subjects covered within the Marine Engineering Syllabi at the CPUT DMS were assessed via two written assessments each during the course of the semester, and a final written assessment that was conducted at the end of the semester. The final assessments were compiled at the CPUT DMS, moderated internally and afterwards sent to SAMSA for external moderation. The intermediate assessments are required to be available for external scrutiny at any time by the external moderators (SAMSA). Each assessment was regarded as one data point for the purpose of this study. During this phase, a sum total of 235 assessments were graded, and the results compared with previous groups of students where a sum total of 249 assessments were graded. These assessment numbers are dependent upon the student enrolment and attendance numbers at the times when the assessments are conducted.

The data recording and analysis for this six month period was done using three software packages, namely (a) Software Open For All (SOFA) open source statistics package, (b) Marks Administration System (MAS) CPUT developed software and (c) on Excel spreadsheets to provide suitable backup and for data analysis.

Certain limitations did exist during this phase, in that the 2013 students were not evaluated in terms of their experience levels as was the case with the rest of the study. Without this like-for-like yardstick of experience/marks correlation, the possibility exists for different student abilities impacting upon the measured outcomes among the respective years. A second contributing factor was that the assessments could not be the same from 2013 to 2014 as was the intention, although the best efforts were made to maintain a similar standard. This was as a result of the requirement to re-configure the syllabi into a logical format (in suitably sizable segments) to work on a CBT platform in line with the revised code requirements.

However, taken that the assessments were of a comparable standard, due primarily to the stringent external moderation process in place, the results from the comparative study are regarded as a true reflection of the outcomes between a purely paper based syllabus (2013) and a purely digital CBT model (2014). This direct data collection process was done in order to ascertain the outcomes from the first phase of the study, through looking at the quantitative outcomes noted in terms of results.

In order to accommodate the confounding variables that existed[64], the data was analysed through the use of three different comparative growth models. These models were chosen to quantitatively compare the results obtained during this phase with

[64] Refer to section 5.6.3 - Study limitations.

those of the previous year's paper-based syllabus, in order that a holistic overview of the results could be attained through the analysis of certain key statistics.

Analysis 1: Statistical Overview

(1) The average (mean) assessment outcomes showed an improvement of 7,97% when the digital syllabus was used in 2014 (65,97%) in comparison to the paper based syllabus that was in use in 2013 (58,00%).

(2) The range of assessment results was noted to be higher in 2014 at 82% in comparison to the 2013 value of 76%.

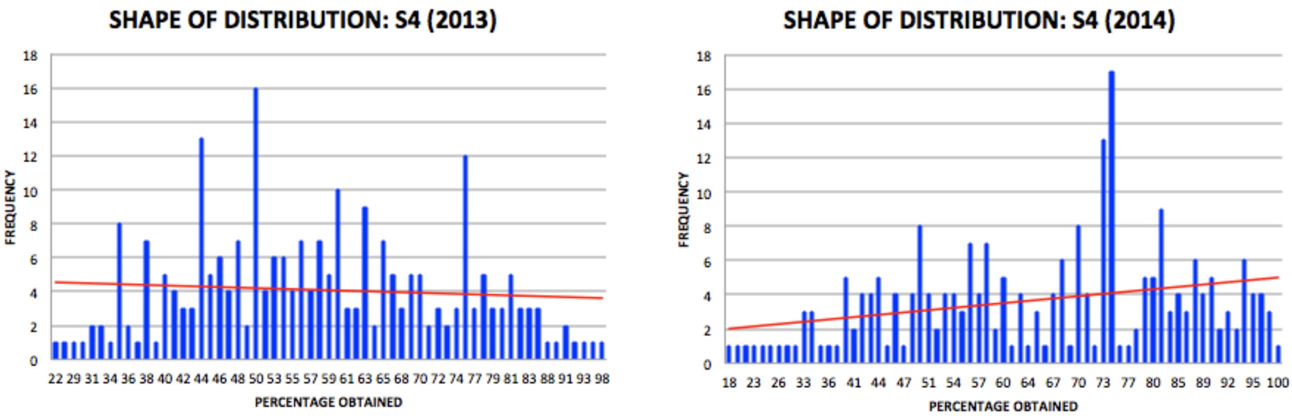
(3) The average deviation in the assessment results was also greater in 2014 at 16,24% in comparison to the 2013 values of 12,85%.

(4) The skewness of the assessment results provided a negative value in 2014 of -0,282 as opposed to the positive value in 2013 of 0,247. Negative skewness is indicative of the asymmetric tail extending to more negative values. This can be clarified through analysis of the two graphs that provide a positive improvement in the shape of the distribution results over the two periods.

STATISTIC	2013 (Paper based) S4	2014 (Computer based) S4
Frequency	249	235
Mean results	58,00	65,97
Average deviation	12,85	16,24
Skewness of results	0,247	-0,282
Range of results	76 %	82 %
Average experience rating	11,06	17,41
% per experience point	5,24	3,79

Figure 44: Table - Statistical analysis comparison

2013 (paper-based) to 2014 (computer-based)



<u>Figure 45: Graph - Shape of distribution of assessment results</u>

<u>2013 (paper-based) to 2014 (computer-based)</u>

Statistical significance: Comparing the 2013 and 2104 results, the calculated t-value of -6,4[65] was greater than the calculated critical t-value of 1,65 (assuming a confidence level of 95%). This indicates that the differences between the 2013 and 2104 sets of results are statistically significant, and not as result of random sampling error.

<u>Analysis 2: Experience-to-assessment outcomes correlation factor</u>

The population sample profiles entered into the system indicated that all of those who responded to the survey had prior seagoing experience of some form or another. Once the assessment and examination results were loaded against each profile, the trend indicated a rather strong positive correlation to exist with a Pearson's *r* value[66] of 0,807.

This correlation strength illustrates the impact that a lack of experience on the part of the student has on academic results in general. This graph is to be reviewed in the third phase of the study, after the introduction of the selected learning methods, to ascertain if any changes are evident with regards to the lesser-experienced students within the group.

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[65] A negative t-value is the same as a positive t-value, the difference between positive and negative indicates the directionality of the relationship.

[66] In statistics, the Pearson product-moment correlation coefficient (Pearson's r) is a measure of linear correlation that exists between two variables X and Y, giving a measure of between (-1) negative correlation and (+1) positive correlation, with (0) being a neutral value.

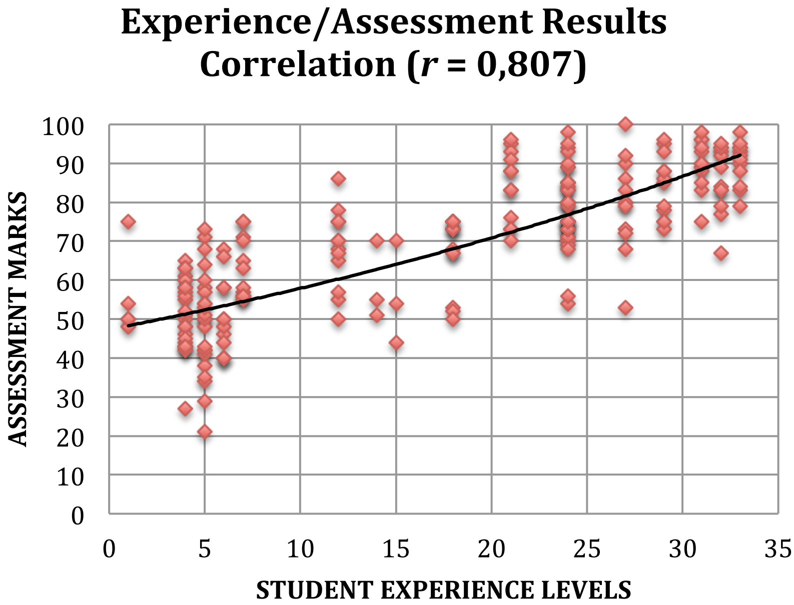

Figure 46: Graph - S4 student analysis survey (2014)

Analysis 3: Proficiency Growth Model: (Growth Model 1)

The first comparative growth model used to compare the assessment results over the two systems in use over successive semesters (termed the 'proficiency growth model') tabled and graphed the outcomes on a comparative line chart to see how well the group of students utilising the CBT model fared in comparison to those using the paper-based model the year before. Due to the successive student groups possessing different academic potentials, the results obtained from this growth model are to be factored into the outcomes from the study in its entirety, once all learning methods that were in use have been analysed, and not used as direct outcomes for this phase of the study (as a result of this confounding variable).

PROFICIENCY	2013 (paper-based) S4	2014 (computer-based) S4
Proficiency Rate (50% and above) All Assessments	170 / 249 68,3%	187 / 235 79,6%
Proficiency Rate (50% and above) Final Examinations	44 / 83 53,0%	64 / 89 71,9%

Figure 47: Table - Written assessment outcomes comparison 2013 (paper-based) to 2014 (computer-based)

The results obtained using the first growth model (proficiency) analysed the 484 assessments that were conducted over the respective six-month periods (2013: 249 and 2014: 235). These results indicate an increase in the overall assessment pass rate for 2014 of 11,2%, (2013: 68,3% and 2014: 79,6%); a finding that factors in an examination pass rate of 18,9% (2013: 53,0% and 2014: 71,9%). The total assessment results over the six-month period showed an overall improvement of 7,97% (2013: 58,0% and 2014: 65,97%) on average, and an improvement in the final examinations assessment outcomes of 8,0% (2013: 52,7% and 2014: 60,7%).

For the final written examinations, the spread of marks proved to be greater in 2014 than 2013, by a factor of 1,27 (2013: 22% - 82% and 2014: 20% - 96%). Despite an improvement overall in 2014, the weaker performing students scored significantly less than the year before after the introduction of computer-based learning, as can be seen from the graph that follows.

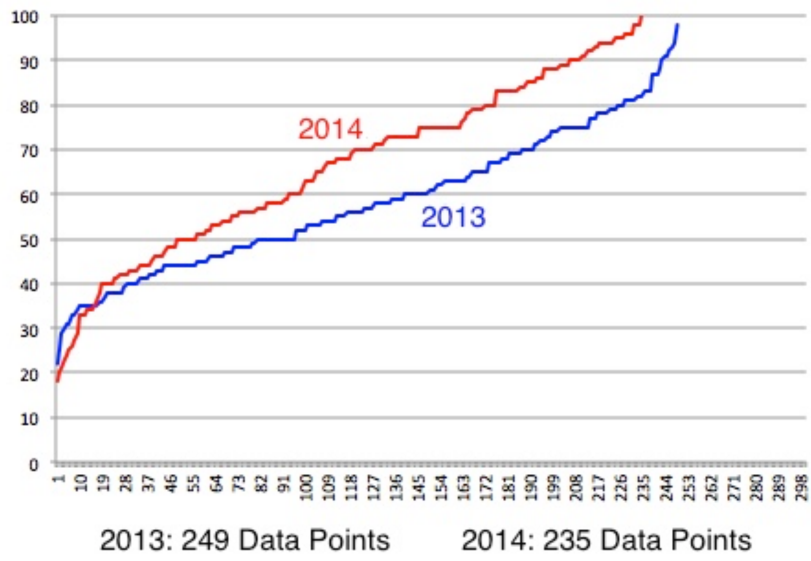

Figure 48: Graph - Written assessment outcomes comparison 2013 (paper-based) to 2014 (computer-based)

A comparison between the assessment results of 2013 and 2014 show that the weakest students in the group in 2014 (computer-based) performed worse than was the case in 2013 (paper-based), despite the overall results being significantly better for the group.

Analysis 4: Performance Index Model: (Growth Model 2)

The second growth model that was used analysed the assessment outcomes (termed the 'performance index model') to categorise the results obtained into percentage groups in order to view the groups in context between one year and the next. The performance index used assessed the outcomes from the final written examinations only, due to the fact that each individual paper is externally moderated by SAMSA (bias reduction). Over the periods under review, a total of 173 examination results were assessed (2013: 83 data points and 2014: 90 data points). The outcomes of the 173 data points assessed over the course of these 2 periods under review, have been categorised as follows:

- 1st category: This category comprised those candidates that were found to not yet be proficient in terms of the assessment outcomes achieved. This group included all of the candidates that attained a mark below 40% for the final written examination in each of the subjects.

- 2nd category: This category comprised those candidates that were required to sit a second supplementary exam for re-assessment purposes. This group included all of those candidates that achieved a mark in the 40% to 49% range for a particular final written examination for any of the subjects.
- 3rd category: This category comprised those candidates that were found to have achieved proficiency in the particular subject final examination, but fell below the threshold required in order to be awarded a distinction for the final examination. This group includes those candidates that achieved a result of 50% and above, but below the 75% required for the distinction, for the final written examination for any of the subjects.
- 4th category: This category comprised those candidates that achieved a distinction. This group of students included those that have been awarded a mark of 75% or above for the final written examination for any of the subjects.

Again, the confounding variable associated with different student groups exists, however it is the intention to place the findings in perspective amongst the spread of results obtained, to ascertain whether or not a positive impact has been registered in any particular category.

Examination Results	2013 (paper-based)	2014 (computer-based)
Below Basic (39% or less)	12,0 %	11,1 %
Basic (40% to 49%)	34,9 %	14,4 %
Proficient (50% to 74%)	47,0 %	44,4 %
Distinction (75% and above)	6,0 %	30,0 %

Figure 49: Table - Written examination outcomes comparison

2013 (paper-based) to 2014 (computer-based)

Analysis using the Performance Index growth model also shows improvements in 2014 over the prior year. The drop in student examination failure rate was marginal at 0,9% (2013: 12,0% and 2014: 11,1%). The student numbers that scored in the 40% to 49% range (those that were required to sit a second supplementary examination) dropped, mainly due to the fact that the proficiency and distinction groups were larger as a collective. The improvement noted was 20,5% (2013: 34,9% to 2014: 14,4%), which represents a significant change over the paper-based syllabus of 2013. The proficiency category (which represents those students scoring above 50%, but below the distinction mark of 75%), changed by 2,6% (2013: 47% and 2014: 44,4%). The distinction candidate numbers showed the largest change, recording an improved with a margin of 24,0% (2013: 6,0% to 2014: 30,0%).

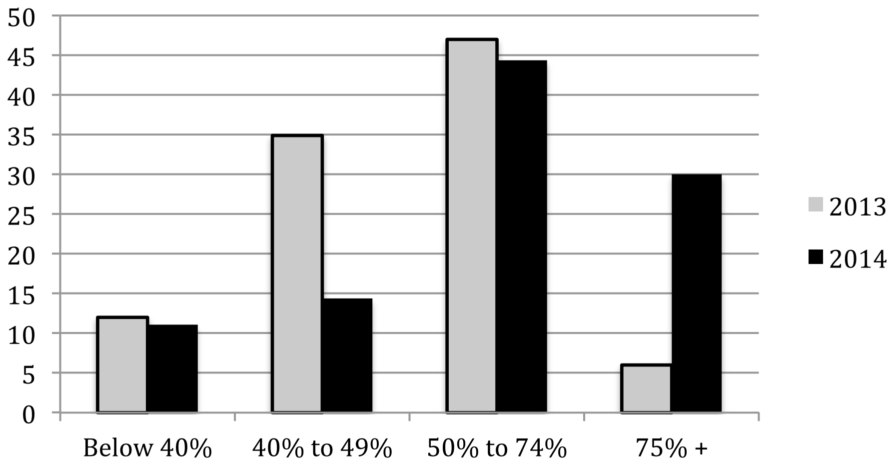

Figure 50: Graph - Performance outcomes within the different categories

Final written examination results: 2013 to 2014

Analysis 5: Simple Growth Model: Growth Model 3

The simple growth model has been used to track the same students who have been studying at the CPUT DMS for two successive semesters, and have thus covered the respective syllabi in both paper-based format in the first semester and the digital format in the second semester. The results will be tabled at Chief Engineering Officer level (S4), against those obtained at Second Engineering Officer level (S3), and will be used for comparative purposes alongside a variable that has been established to determine a standard alteration in results between the two successive study levels among the rest of the S4 students. In this way, the students included in this model can be viewed against those students who have not served successive semesters.

This index was selected as a data collection tool as it discounted the confounding variable associated with the previous two growth models, namely that of the different student groups being analysed. The downside associated with the use of the simple growth model in this case is that there are very few students that complete successive semester studies. The total analysed represented a cumulative total of 14 students (8 students in 2013 and 6 students in 2014).

In 2013, both of these successive semester syllabi were paper-based, however this changed in 2014, when the second semester syllabi changed to digital-based from paper-based in the first semester. Owing to the fact that it is the same students measured, the index more clearly represents a measurement of the learning method used over the course of the study.

A sum total of 400 data points were analysed between 2013 and 2014, with each data point representing one written assessment of one written examination (2013: 256 and 2014: 144). In 2013 there was a decrease in the marks in the second semester from the first semester by 4,99%, which was mirrored in 2014 by a similar drop in marks of 5,03%. In terms of the final written examinations, a total of 112 data points were analysed (2013: 64 and 2014: 48). These results showed a noticeable drop from a 2,09% decrease in 2013 to a 6,36% decrease in 2014.

PAPER SYLLABUS vs. PAPER SYLLABUS				PAPER SYLLABUS vs. DIGITAL SYLLABUS			
STUDENT	S3 (2013)	S4 (2013)	CHANGE	STUDENT	S3 (2014)	S4 (2014)	CHANGE
Student 1	58,63 %	55,42 %	- 3,21 %	Student 9	66,58 %	63,08 %	- 3,50 %
Student 2	61,81 %	62,50 %	+ 0,69 %	Student 10	73,25 %	68,00 %	- 5,25 %
Student 3	74,63 %	73,67 %	- 0,96 %	Student 11	51,42 %	53,08 %	+ 1,66 %
Student 4	56,44 %	51,00 %	- 5,44 %	Student 12	49,50 %	40,50 %	- 9,00 %
Student 5	52,00 %	51,92 %	- 0,08 %	Student 13	64,58 %	58,33 %	- 6,25 %
Student 6	52,63 %	44,42 %	- 8,21 %	Student 14	57,92 %	50,08 %	- 7,84 %
Student 7	59,69 %	47,17 %	- 12,52 %				
Student 8	57,19 %	47,00 %	- 10,19 %				
AVERAGE CHANGE			- 4,99 %	AVERAGE CHANGE			- 5,03 %

Figure 51: Table - Written assessment & examination outcomes comparison

2013 and 2014 Comparisons using the Simple Growth Model

As these groups contained the same student dynamics from semester to successive semester, the overriding confounding variable mentioned in the first two index measurements had been discounted, with the aim of producing a true reflection of the outcomes of the various syllabus delivery methods. The results indicate that despite the positive observations surrounding the use of the digital-based syllabus mentioned previously, there is inconclusive evidence that a change to a digital syllabus has resulted in better outcomes over the previously used paper-based syllabus, with the results producing negative results in comparison to the change noted in 2013.

Summary of the quantitative analysis for (CBT) scaffold learning outcomes

Through the basic statistical analysis that was done, and by factoring in the results from the three growth models that were used, the following trends can be identified:

(1) Statistical analysis: For this particular phase of the study, the mean results showed a positive change of 7,97 %. The 'shape of distribution' graphs indicate that the trend line altered from a negative value to a positive value upon introduction of the digital syllabus, as a result of a more positive results distribution pattern.

(2) Basic proficiency model: In terms of basic proficiency (growth model 1), an overall improvement was noted in pass rates of 11,3% over all of the assessment counted, and a 18,9% improvement in the pass rate noted at the examination level. The weakest performing students fared worse than those using the previous paper-based course, as can be seen from the basic proficiency graph that includes all of the data points.

(3) Performance index model: In terms of the various performance groups (growth model 2), the weakest performing students academically (39% or less examination score) showed very limited positive improvements at a figure of 0,9% when compared to other groups. Better improvements were noted across the range in general within the three remaining groups, where a large portion of students moved from the basic band (40% to 49%) into the proficient band (50% plus), which represents an examination pass. At the higher end of the range analysed, the 2014 distinction candidate (75% plus) numbers showed a marked improvement when compared to the numbers in 2013.

(4) Simple growth model: The simple growth model (growth model 3) arguably represents a truer reflection of the learning method used, as the same students in successive semesters are tracked. However the results that were obtained were from a very small sample as only a limited number of students attend successive semesters.

One important variable needs considering in that as the students are following up their studies successively, they fall into the category of students that lack any form of prior seagoing experience at the level of academic study they have just completed. As noted in the simple growth model table of results, negative outcomes were noted among these particular students when the digital syllabus was introduced in comparison to the previous group who had successive paper based syllabi.

An observation worth considering from this phase of the study that was completed, is that whilst improvements were noted in mean assessment values, it is the better performing students who reaped the most benefits from the introduction of the digital syllabi. The students at the lower end of the scale academically showed very little change in terms of assessment results, as did the ‘inexperienced’ students who attended successive semesters without any form of prior practical experience.

7.2.2 Research sub-question 1: Methods analysis

Initial researcher observations observed through the action research process highlighted the fact that there was a distinct improvement in the levels of student awareness with the e-learning method of instruction. Placing students behind laptops, to facilitate their own learning process as the lectures took place, resulted in the fatigue levels being notably lower. This is most likely due to the engagement levels being higher than the chalk-and-talk method of tuition.

Having the ability for the students to participate in the manner that they are able to in an information-sharing environment has meant that the postings from the students has contributed to the modernisation of the syllabus itself. In this way, the theoretical equipment related concepts are supplemented with additional, modern, shipboard relevant alternatives to those items studied in the classroom.

In terms of surveyed data, indirect data collection was conducted via a second survey in order to garner qualitative data from those students who have attended class at CPUT, and who have received tuition in both the paper-based and CBT models for Marine Engineering. In total, 28 surveys were distributed, from which there were unfortunately only 12 responses. The items covered within this distributed survey (survey 2) include the following:

(i) Course layout and configuration: This section was aimed at gathering data about the perceived positive and negative elements regarding the CBT model design (constructionist elements) in comparison to the previously used paper-based model that preceded it. This question included aspects such as course layout, use of visual media and ease of information retrieval

(ii) Course engagement: This second section of the survey was designed to retrieve information as to which of the two syllabi were better able to engage the student in terms of participation, and which of the two systems was better able to maintain an interest in the subject matter (scaffold process & scaffold map assignment use).

(iii) Time allocation: The third survey question asked those participating which of the two systems they felt resulted in them spending the most amount of time engaged with the subject material.

(iv) Course planning: This segment of the survey was inserted to ascertain whether or not the students' felt that the nature in which the subject matter had been compartmentalized in the digital guise, had any improvements in their ability to manage their study time better (constructionist elements).

(v) Assignment map usage: For this study, the use of and submission of the weekly assignment maps (compiled in different learning and thinking style variants) replaced the previously used written project that accompanied the paper-based syllabus. This section of the survey was configured to gather data regarding whether or not the students felt the concept map assignment had more merit in terms of relevant information, in comparison to a written project. A second aim behind this question was to determine which of the two systems required the students to make more use of textbook material to complete the required work items.

(vi) Future CBT development: The last survey segment was inserted to allow for freedom of expression with regards to how the students themselves felt the CBT model could be improved upon in the future, and which of the current components of the course should be omitted going forward.

Data collected from this qualitative survey was used alongside the quantitative growth model data retrieved, in order to determine the impact of this first phase of the study over previous methods of tuition used at the CPUT DMS.

<u>Constructionist design & scaffolding elements analysis</u>

From student feedback received (survey 2), there were certain positive enhancements noted from the change from paper syllabi to a scaffold orientated CBT format for the management of the course material. These include the following key elements, summarised in figure (table) 52.

CBT Constructionist Design Elements (Scaffolding)		
Course Layout	Books & Paper (Better)	Concept-Mapping (Better)
	3	9
Visual Media Use	Sufficient	Insufficient
	8	4
Information Retrieval	Books & Paper (Faster)	Concept-Mapping (Faster)
	3	9
Time Spent with Material	Books & Paper (More)	Concept-Mapping (More)
	8	4
Course Planning	Books & Paper (Better)	Concept-Mapping (Better)
	4	8
Textbook Use	Books & Paper (Better)	Concept-Mapping (Better)
	7	5

Figure 52: Table – Scaffold design analysis of devised CBT model

- Information retrieval time: Access to information was stated as being a simpler and quicker process by 9 of the 12 survey respondents, which is in agreements with Mayer & Moreno's (2002) findings. In addition, the lookup within a definitive boundary (one subject per page) was appreciated ('mountain-top' view, Chatterjea & Nakazawa, 2008).
- Planning: The use of a more structured course outline and guided direction process through the scaffold learning design elements were stated as an improvement by 8 of the 12 respondents.
- Convenience: Within the open-ended section of the survey (survey 2), the fact that all information pertinent to that subject had the sources available from one platform was appreciated.
- There was disagreement as to which form encouraged greater use of textbook material, with 7 of the 12 respondents feeling that the paper-based syllabus held the advantage in this area.
- Time: Despite the assignments requiring time to be put in for completion and submission, 8 students among those sampled beleived that the previously used

paper-based syllabus required more time to be allocated to the studies than was the case with the computer-based method of tuition.

The following key points were listed by the students within the open-ended portion of the survey as being important:

(a) The process of condensing fairly large volumes of text into understandable size portions through the use of the concept maps and assignment maps was stated as being an improvement within the open-ended section of the survey.

(b) The group dynamics was stated as being a positive within the open ended section of the survey, as the interactive nature that concept mapping allows enhanced the spread of information. This element of the course was believed to be an improvement on the chalk and talk method of content delivery, especially given the requirement regarding the assignment maps and after-hours correspondence. Social interaction was tested as a learning method (GBL) in the final phase of the study.

(c) In terms of the S1 and S2 students, it was questioned by the management students as to whether or not the lack of industry experience, coupled with the limited time available to cover the prescribed texts would render the CBT model ineffective as a method of tuition at the lower levels.

The final concern regarding the usage of the system at the junior levels comes about as a result of the workload that is required to be covered during the course of the semester. In a situation such as this, the students stated their wish to reduce the cognitive load as much as possible, preferring to revert to the paper text as the source of information, as it is deemed by them that this is where the examination questions are going to come from anyway, and that digital imagery 'cannot be examined'.

<u>Thinking and learning style use analysis</u>

Analysis of the thinking and learning styles catered for during this phase of the study primarily focused on the form that the various assignment maps that were constructed in line with Stenberg's thinking style model and Kolb's learning style model (section 2.3). The form of these maps was designed to cater for the following thinking and learning styles of the students, with each student having maps more suited towards their preferred styles of thinking and learning:

- Research based assignments:
  (Sternberg: 'Legislative' function, global level, conservative and liberal leanings).
  (Kolb: Reflective learning style students).

- Procedural based assignments:
  (Sternberg: 'Executive' function, monarchic form, local level, conservative leaning).
  (Kolb: Reflective learning style students).

- Sequential based assignments:
  (Sternberg: Hierarchic form, local level, conservative leaning).
  (Kolb: Reflective style students).

- Cause and correction assignments:
  (Sternberg: 'Judicial' function, oligarchic form, global level, liberal leaning).
  (Kolb: Active learning styles).

- Shipboard system assignment maps:
  (Sternberg: Anarchic form, global level, conservative leaning).
  (Kolb: Active and reflective learning styles).

The 80 scaffold map assignments used during this phase of the study were not graded in terms of assessment marks, but were required to be submitted to the lecturer via Email for a participative mark on the MAS system. For that reason, the outcomes in terms of the effectiveness of the thinking and learning style strategies used are to be viewed holistically against the backdrop of the quantitative statistical analysis conducted.

The limited thinking and learning styles relevant data received from the survey conducted at the end of the semester (survey 2), produced the following results:

<table>
<tr><th colspan="7">Assignment Map Design Elements (Thinking & Learning Styles)</th></tr>
<tr><td rowspan="2">Course Engagement</td><td colspan="3">Books & Paper (Better)</td><td colspan="3">Concept-Mapping (Better)</td></tr>
<tr><td colspan="3">3</td><td colspan="3">9</td></tr>
<tr><td rowspan="2">Assignment Map Effectiveness</td><td colspan="2">Positive</td><td colspan="2">Negative</td><td colspan="2">Not Sure</td></tr>
<tr><td colspan="2">6</td><td colspan="2">3</td><td colspan="2">3</td></tr>
</table>

Figure 53: Table – Thinking and learning style analysis of devised CBT model

- Engagement: 9 of the 12 surveyed reached consensus that the computer-based syllabus was better able to engage the students, and retain the focus better that a paper-based syllabus.
- Assignment map effectiveness: The question asked in this section of the survey centered around the ability of the 'procedure-based' and 'sequence-based' maps in terms of assisting the more junior students with regards to the understanding of engineering systems. 6 of the 12 respondents indicated that the maps would have a positive affect, 3 indicated no affect and 3 were unsure. The largest concern in this regard (from the open-ended survey section) was with respect to the volume of work required of the syllabi.

7.3 RESEARCH SUB-QUESTION 2: Computer-aided learning analysis

The S3 class of 2015 was unlike any that had come before at the CPUT DMS, in that a large portion of the students who were now studying at a senior (shipboard management) level had no prior seagoing experience. At the request of the maritime industry, the S2 students from the semester before were admitted to the S3 management program at the CPUT DMS in January 2015 as a result of there being a lack of available training berths for them to get the necessary sea time. At the time, the dedicated training vessel that was used by SAMSA to send the cadets to sea was unavailable due to a funding related issue. Due to a shortage of qualified lecturing staff and classroom infrastructure, it was not possible to split the class into two groups; one containing those that had prior seagoing experience, and the other containing those students who had never been to sea before.

In total, 46 students started the S3 course, but only 29 students were able to complete the program due to the increased workload involved in comparison to studying at the lower level. This unprecedented dropout rate of 37% is attributable to both these students being poorly prepared academically, and through them being disadvantaged by having no prior industry experience. At CPUT it is policy that poor academic performance during the course of the semester can result in the students being excluded from further studies at the institution. Rather than risk this, many students withdraw after the mid-term assessments once they realise that the possibility of exclusion may become a reality for them. If a student withdraws from the program, they cannot be academically excluded from future study, as no results are captured against their profile.

A second contributing factor comes from the fact that many of these students are on bursaries to study Marine Engineering, in an attempt to develop the maritime sector. These bursaries were awarded to students from around South Africa, to include both the course fees and money for monthly expenses, for the duration of their study period. For a large sector of the bursary students, Marine Engineering was not always their first choice of study. Acceptance of Marine Engineering bursaries is often a personal compromise for the after they were unable to secure funding for their preferred study stream (i.e. Mechanical or Chemical Engineering).

Despite the results being captured for all of the participating students as part of this study, in terms of analysis, only those students that have seen the course through to completion will be factored in to ascertain the effectiveness of the CBT program. This is to enable the outcomes to reflect on the study in its entirety.

This phase of the study examined the impact that a change from a purely paper-based syllabus to a computer-aided syllabus had on the students at this level (S3).

7.3.1 Research sub-question 2: Statistical data analysis

The computer-aided learning part of the study ran from February to June 2015, with the participants comprising those students studying towards their Second Engineering Officer certificate of competency.

The four subjects covered in this part of the study are assessed via three written assessments during the course of the semester, and a final written assessment at the end of the semester. The assessments and final examination were compiled at CPUT, moderated internally and placed available for external moderation by SAMSA. Each assessment was regarded as one data point for the purpose of this study. During this phase of the study, data from the assessments was collected as follows:

(a) In order to ascertain the outcomes of whether or not a software model could adequately make up for the students having limited industry exposure, a sum total of 553 assessments were graded. This number represents the sum total of assessments written by every registered student. These data points also included the 37% drop out rate portion.

(b) In order to assess the effectiveness that a computer-aided CBT model of education had on those students who completed the course in its entirety, 490 of these 553 assessments were used for analytical purposes. The 490 data points represented those students who stayed in the system throughout.

In 2014, the students that participated in the survey were evaluated in terms of their experience levels, as were those who participated in the class of 2015. Whilst the confounding variable of different student groups again exists, the quantitative results obtained from these respective years should be viewed in light of the respective experience levels. The 2015 mid-term assessments, although not exactly the same, covered the same syllabus sections, as was the case in 2014. Again, the intention was to maintain a similar standard of questions asked over the successive years.

Accepting that the assessments were of a comparable standard, due primarily to the moderation process at the S3 level, the results from the comparative study are regarded as a true reflection of the outcomes between a purely paper based syllabus (2014) and the computer-aided learning approach that was introduced in 2015. This data was analysed statistically in a similar to the first study, with the addition of the Bloom's taxonomy analysis that was introduced. The intention was to again compare results obtained with those of the previous year's paper-based syllabus.

Analysis 1: Statistical Overview

(1) The average (mean) assessment outcomes showed marginal increase of 1,24% when the computer aided version was used in 2015 (59,16%) in comparison to the paper based syllabus of 2014 (57,92%).

(2) The range of assessment results was higher in 2015 at 93% in comparison to the 2014 values of 77%.

(3) The average deviation in the assessment results was greater in 2015 at 13,90% in comparison to the 2014 values of 11,71%.

(4) The skewness of the assessment results increased marginally in a negative direction to a value of -0,379 in 2015 as opposed to the 2014 value of -0,208.[67]

STATISTIC	2014 (paper based) S3	2015 (computer aided) S3
Frequency	239	490
Mean results	57,92 %	59,16 %
Average deviation	11,71 %	13,90 %
Skewness of results	-0,208	-0,379
Range of results	77 %	93 %
Average experience rating	11,06	7,52
% per experience point	5,24 %	7,87 %

Figure 54: Table - Statistical analysis comparison: S3 level students 2014 (paper-based) to 2015 (computer aided)

[67] Negative skewness is indicative of the asymmetric tail extending to more negative values.

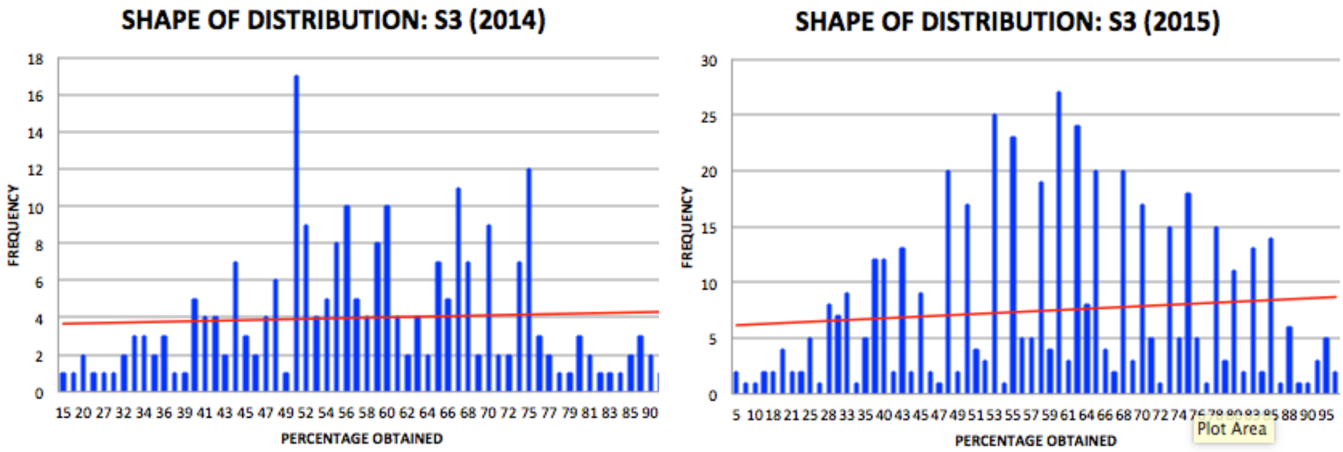

Figure 55: Graph - Shape of distribution of assessment results: S3 level students 2014 (paper-based: left) to 2015 (computer aided right)

Statistical significance: Comparing the 2014 and 2105 results, the calculated t-value of 0,1 was less than the calculated critical t-value of 1,65 (assuming a confidence level of 95%), indicating the differences between the 2014 and 2105 results cannot be called statistically significant and could be as result of random sampling error.

Analysis 2: Experience-to-assessment outcomes correlation factor

The population sample profiles entered into the system for this phase indicated that 20 out of the 38 who responded to the survey had no prior seagoing experience. Once the assessment and examination results were loaded against each profile, the trend indicated a positive correlation to exist with a Pearson's *r* value[68] of 0,572.

This correlation strength again illustrates the impact that a lack of experience on the part of the student has on academic results, especially since the result is a large departure from a negative correlation of -0,058 recorded in 2014, when the entire population sample indicated prior seagoing experience on their part.

[68] In statistics, the Pearson product-moment correlation coefficient (Pearson's r) is a measure of linear correlation that exists between two variables X and Y, giving a measure of between (-1) negative correlation and (+1) positive correlation, with (0) being a neutral value.

This graph is to be reviewed in the third phase of the study, after the introduction of the selected learning methods, to ascertain if any changes are evident when the majority of these students move to the next level (S4) of study.

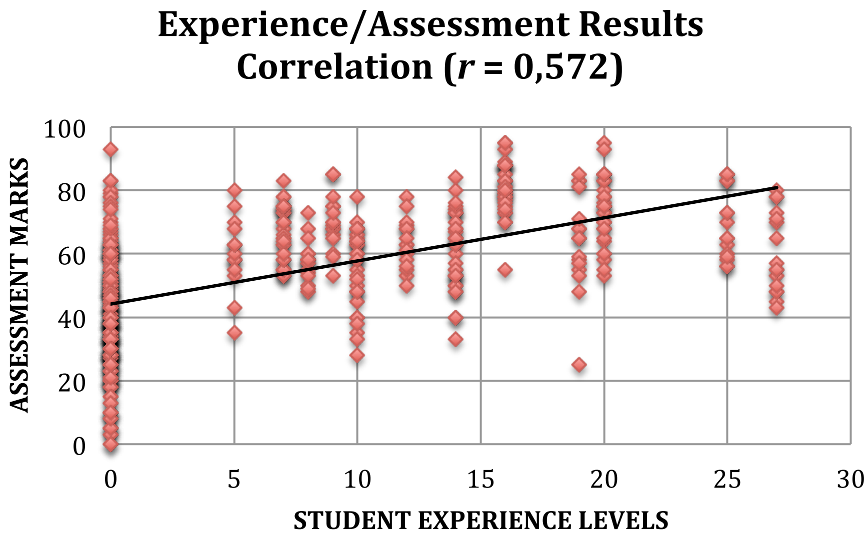

Figure 56: Graph - S3 student analysis survey (semester 1, 2015 – Second Engineers)

Analysis 3: Growth Model 1: Proficiency

The proficiency growth model tabled and graphed the outcomes to see how well the group of students utilising a computer aided approach to learning fared in comparison to those using the paper-based model the year before.

Proficiency Rates	2014 (Paper-based)	2015 (Computer aided)
All Assessment Proficiency Rate (50% and above)	179 / 239 74,9%	363 / 490 74,1%
Final Examination Proficiency Rate (50% and above)	59 / 79 74,7%	94 / 120 78,3%

Figure 57: Table - Written assessment proficiency comparison

2014 (paper-based) to 2015 (computer aided)

The results obtained using growth model 1 (proficiency), that analysed the 729 assessments conducted over the six-month periods (2014: 239 and 2015: 490), indicate a decrease in overall assessment pass rate for 2015 of 0,8%, (2014: 74,9% and 2015: 74,1%). In terms of the final written assessments, the outcomes over the six-month period showed an overall improvement of 3,6% (2014: 74,7% and 2015: 78,3%).

The spread of marks was greater in 2015 in comparison to 2014, which can be expected due to there being more than double the amount of assessment results analysed. The spread of results increased over this period by a factor of 1,21 (2014: 15% - 92% and 2015: 5% - 98%).

Analysis 4: Growth Model 2: Performance Index model

The performance index model categorised all of the 729 written subject assessments over the 2014-2015 period as follows:

Examination Results	2014 (paper-based)	2015 (computer aided)
Below Basic (39% or less)	9,2%	13,0%
Basic (40% to 49%)	15,9%	12,9%
Proficient (50% to 74%)	60,3%	53,1%
Distinction (75% and above)	14,6%	21,0%

Figure 58: Table - All written assessment outcomes comparison

2014 (paper-based) to 2015 (computer aided)

A review of all of the semester assessment outcomes indicate that the outright failure rate increased by 3,8% (2014: 9,2% and 2015: 13,0%). The number of assessment results in the 40% to 49% range (not yet proficient) declined in 2015 by 3% (2014: 15,9% and 2015: 12,9%).

The proficiency rate (representing those assessment results in the range of 50% to 74% declined by 7,2% (2014: 60,3% and 2015: 53,1%), however the distinction range (75% and above) recorded an improvement of 6,4% (2014: 14,6% to 2015: 21,0%).

The performance index model categorised the 199 final written subject assessments (examinations) over the 2014-2015 period as follows:

Examination Results	2014 (paper-based)	2015 (computer aided)
Below Basic (39% or less)	8,9%	8,3%
Basic (40% to 49%)	16,5%	13,3%
Proficient (50% to 74%)	68,4%	64,2%
Distinction (75% and above)	6,3%	14,2%

Figure 59: Table - Written examination outcomes comparison

2014 (paper-based) to 2015 (computer-aided)

Analysis using the performance Index growth model indicates that, in general, improvements have been noted in terms of assessment results using a blended learning model as opposed to the previously used paper-based syllabus. The outright failure rate declined by 0,6% (2014: 8,9% and 2015: 8,3%). The number of assessment results in the 40% to 49% range (mot yet proficient) also declined in 2015 by 3,2% (2014: 16,5% and 2015: 13,3%).

The proficiency rate (representing those assessment results in the range of 50% to 74% declined by 4,2% (2014: 68,4% and 2015: 64,2%), however the distinction range (75% and above) recorded an improvement of 7,9% (2014: 6,3% to 2015: 14,2%).

Analysis 6: Simple growth model

This analysis was not done at this stage as the students (S3) are at the first management level.

7.3.2 Research sub-question 2: Blooms taxonomy assessments analysis

Analysis 7: Blooms revised taxonomy review

The General Engineering Knowledge subject assessments for this semester were set to cover levels one to five of the Blooms revised taxonomy model, as level 6 (the creation of knowledge was deemed to fall outside of the requirements of a diploma program. Assessments were designed from the outset to cover these disciplines within the model to varying extents, which were to be categorised upon completion. This was to be done to provide an indication of the level of understanding that took place. A sum total of 68 data points were analysed, which represented the total of assessments written for that particular subject. Of this total, 39 assessments were graded at the beginning of the semester (1^{st} assessment) and 29 were graded towards the end of the semester (2^{nd} assessment). The results from these findings are listed below.

With both assessments taken into account, the lower order skills component (comprising the remembering and understanding skill sets) scored class mean values of 57,8% and 55,0% accordingly. The mid-level components of application and analysis achieved mean values of 49,2% and 44,7% respectively, whilst the higher order skill set of evaluation achieved 46,7%.

(i) Level1 - Remembering (57,8%): Questions from this level of the Blooms revised taxonomy model comprised 22,5% of the total questions asked (20% in the first assessment, and 25% in the second assessment). The mean mark obtained over the two assessments was one of only two layers within the revised taxonomy model that recorded a result of over 50%, which is the subject pass. This results needs to be taken into consideration with regards to the qualitative data analysis conducted whereby a concern was raised as to the amount of information required for the course. Concerns were raised that the volume of work required is excessive given the available time frame, and that the revised SAMSA code requirements had increased the volume of work required in recent years. Students are required to take nine subjects over a six-month period to cover both the part A (the technical component) and part B (the maritime component) simultaneously. As this was the highest scoring section from within the taxonomy model, the stated concern of information overload in not truly reflected in the marks from this portion of the study.

(ii) Level 2 – Understanding (55,0%): Questions from this level of the Blooms revised taxonomy model comprised 43,4% of the total questions asked (38,3% in the first assessment and 48,4% in the second semester). This drop in percentage value from the pure recall of subject knowledge is in line with how the lesser-experienced students will naturally be challenged when the knowledge recalled has to be placed in perspective and understood. The mark obtained from the understanding portion within the revised taxonomy model was marginally above the 50% pass required of the subject.

(iii) Level 3 – Application (49,2%): Questions from this level of the Blooms revised taxonomy model comprised 10,8% of the total questions asked (13,3% in the first assessment and 8,3% in the second assessment). These questions related to practical tasks that were required to be carried out onboard a ship. Again, any lack of seagoing exposure resulted in many of the students being required to memorise these unfamiliar tasks and shipboard procedures without being able to recall knowledge from long term memory. The mark obtained from the application portion within the revised taxonomy model was marginally below the 50% pass required of the subject.

(iv) Level 4 – Analysis (44,7%): Questions from this level of the Blooms revised taxonomy model comprised 9,2% of the total questions asked (11,7% in the first assessment and 6,7% in the second assessment). Results obtained from this section represented the lowest marks obtained from within the six categories of the model. As the students were required to present the answers in their own words, and explain which option they would choose to solve certain practical scenario's, the unfamiliarity that many of the students have with regards to onboard systems was highlighted in these results. The mark obtained from the analysis portion within the revised taxonomy model was below the 50% pass required of the subject.

(v) Level 5 – Evaluation (46,7%): Questions from this level of the Blooms revised taxonomy model comprised 14,2% of the total questions asked (16,7% in the first assessment and 11,7% in the second assessment). These questions related to the students being given certain systems where they were required to identify or explain certain faults that were indicated. The format of the questions represented certain scenarios whereby junior engineers onboard reported to them as senior engineers, certain faults that they have identified. It then became the requirement to fault-find, identify causes and provide possible solutions. Again, the results obtained from this segment indicate (in part) a lack of seagoing practical knowledge in many cases. The mark obtained from the evaluation portion within the revised taxonomy model was below the 50% pass required of the subject.

(vi) Level 6 – Creating. In line with keeping the level of questioning at a level of a diploma programme, and to satisfy the requirements of the external moderation process held at SAMSA, questions asked fell outside of the top level of the Blooms revised taxonomy model.

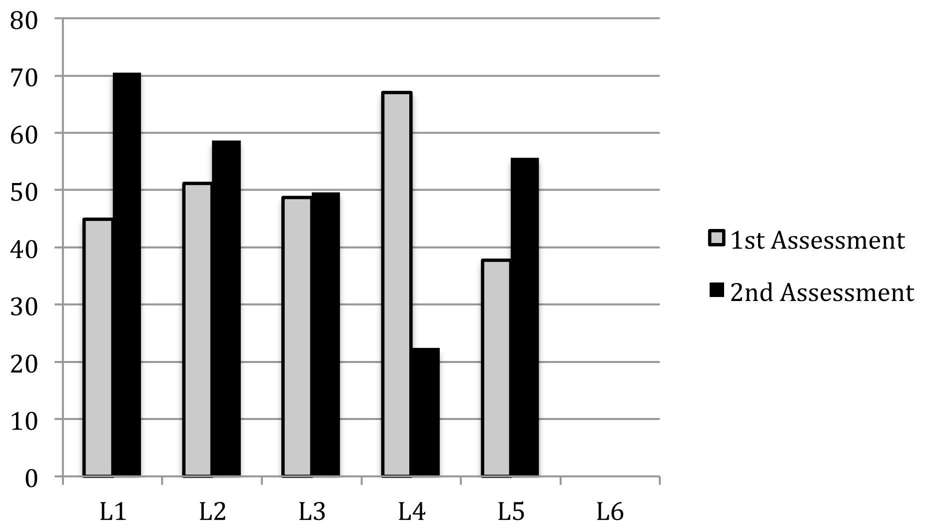

Figure 60: Chart - Blooms taxonomy outcomes comparison

When the results are graphed, the findings indicate that the students perform the best in terms of the recall of subject knowledge. The findings however also indicate that the students underperform in the areas of understanding, application of knowledge learned, analysis and the evaluation of knowledge.

7.3.3 Research sub-question 2: Methods analysis

A qualitative survey was conducted at the end of this stage of the study (survey 3), to gather and analyse data regarding the use of CBT technology as a method of tuition at the Second Engineering Officer level (S3). In total, 29 surveys were received from the 38 distributed within the class, from which information was retrieved with regards to the following key points:

(i) Course delivery preference. The students were required to list their preferred choice of study materials for this level. The option for this choice was between (i) a purely textbook and paper-based text component of the syllabus, (ii) documentation in the form of computer files for the text component or (iii) both options provided to the students, thereby allowing them to move between the two mediums as required.

(ii) Volume of information. The second survey question asked the students to choose between the following two questions:

(a) "The amount of work was too much, my main aim was to learn just what is required to pass the assessments"
or

(b) "I used all of the information provided to try and understand the subject material the best that I could".

The reasoning behind this was to ascertain the degree of information overload as perceived by the students, and to determine to what degree the CBT media files were used to complement the text component of the course.

(iii) Assistance to those students who have never been to sea before. The question posed the question that given the available time frame with which to run the course, to what degree does a CBT model have the ability to help those students who have never been to sea before. The feedback in this regard was also used to see if the students believed if it was possible to replace the experience of never having seen any of the components, with CBT media use.

(iv) Positive and negative aspects regarding the use of classroom CBT. The concluding part of the qualitative survey asked for feedback regarding the students perceptions of the course and the course material.

Constructionist design & scaffolding elements analysis

The findings from this survey have been documented in figure (table) 61. In each case, totals that do not add up to 29 are as a result of omitted survey information.

<table>
<tr><th colspan="4">CBT Constructionist Design Elements (Scaffolding)</th></tr>
<tr><td rowspan="2">Course Delivery Preference</td><td>Books & Paper</td><td>Digital Files</td><td>Both Paper & Digital Files</td></tr>
<tr><td>14</td><td>8</td><td>7</td></tr>
<tr><td rowspan="2">Volume of Information</td><td colspan="2">Information Overload, Assessment Pass Prioritised</td><td>Resources utilised, deeper understanding prioritised</td></tr>
<tr><td colspan="2">8</td><td>20</td></tr>
</table>

Figure 61: Table - Constructionist (scaffolding) design feedback

The preference towards the course text being provided in paper format is largely attributed to the students desire to reduce the volume of information at their disposal. Many preferred material in which they can highlight important points, and track back and forward between sources. This was stated as being easier to do with printed material than is the case when the opening and closing of text based computer files is required. This finding was in contrast to the more senior group of students the semester before, which may be attributable with the degree of unfamiliarity the students have with regards to studying with the aid of a computer.

In general, these survey results (although limited in number) do not concur the often felt belief that most learners are deductive, and that they desire only enough information to pass the examination, nothing more or less. This is likely as a result of the industry requiring a competency assessment before certification is awarded, and as such the desire to retain knowledge through a deeper understanding of the topics becomes evident on the part of many students.

Despite prior findings that information retrieval was seen as being faster within the concept mapping platform (as a result of the scaffold nature of the design), many students were of the opinion that paper text should accompany digital files. Due to the fact that such a large percentage of the class had no prior shipping experience, the digital files were not viewed as an 'aid' to understand the text component (as the more experience students generally do), but rather as just additional unfamiliar 'items' that they have to learn in addition to the text.

Thinking and learning style use analysis

After the completion of the 80 assignment maps that were devised in a format that could cover the range of thinking and learning styles described, a simple question was asked within the survey as to the ability of these types of exercises to aid students who had never been to sea before. The results to this question are tabled below:

Assignment Map Design Elements (Thinking and Learning Styles)				
Can a CBT program assist those students who have never been to sea before?	Not really	Limited Help	A Lot of Help	Completely
	0	10	12	7

Figure 62: Table - Thinking and learning style analysis of devised CBT model

In terms of whether or not a CBT model of Marine Engineering education has the ability to 'make up' for a lack of prior experience on the part of many of the students, the consensus was that the assignment map designs (procedure-based, sequence-based etc.) could be of benefit to those who have never been to sea before. None of the surveyed participants felt that a CBT model would not benefit inexperienced students. 34% believed that a CBT model would only be of limited help, 41% felt that a CBT model would go a long way to compensate for a lack of prior industry exposure, and 24% felt that a CBT model could completely make up for a lack of prior industry experience.

Summary

With regards to the feedback received from the open-ended question portion of the survey, the greatest component lacking from a course of this nature, is some form of practical exposure to shipping components and practices (24% of sample). This practical element also ties in with a lack of ship visits being a concern (7% of sample). As these percentages were relatively small, it would suggest that (in this regard) there is support for the view of Joseph Novak that "*Technology could be used to counter a lack of available resources, in order to improve student academic outcomes*".

The second largest concern among those surveyed was that there could be greater use made of video media (17% of sample), which also ties in a concern with the limited simulator exposure at the CPUT DMS (7% of sample).

Whilst paper remained the preferred choice for the students in terms of the text component of the course, the surveyed results indicate that a CBT model that makes use of participative assignments was generally viewed as a tool that can positively assist those students who lack seagoing experience. It was felt that the CBT model devised has the ability to complement the paper text to enhance the understanding of the subject material, whilst to some extent, compensate for a lack of available resources. Whilst little can be done to include practical components and ship visits into the course (largely due to infrastructure constraints, time availability and the large class sizes), those surveyed believed that greater use of visual media would be of benefit to the students.

7.4 RESEARCH SUB-QUESTION 3: Analysis of the use of the selected learning methods

The S4 class of 2015 again comprised the senior level students within the Marine Engineering study stream. Experience levels within this group were not what they were at this level the year before, due to the fact that some of those students previously mentioned who were lacking in industry experience have progressed through to the final study level.

In total, 31 students started the S4 course, of which 6 students had no prior seagoing experience.

This phase of the study examined the impact that the introduction of the selected learning methods (CBL and GBL) had on student outcomes at this level (S4).

7.4.1 Research sub-question 3: Statistical data analysis

The introduction of the selected learning methods took place in July 2015, with the participants comprising those students studying towards their Chief Engineering Officer certificate of competency (S4). GBL and CBL were used in tandem throughout the semester, therefore the outcomes from this part of the study are to be viewed under 'CBT and the introduction of selected learning methods', and not individually.

The four subjects that are covered in this study are assessed via two written assessments that are undertaken during the course of the semester, and a final written assessment that takes place at the end of each semester. The final assessments are compiled at CPUT and sent to SAMSA for external moderation, with the intermediate assessments required to be available for external scrutiny at any time by SAMSA. Each assessment was regarded as one data point for the purpose of this study. During this phase, a sum total of 300 assessments were graded, and the results compared with previous groups of students.

The syllabus content remained the same as the previous S4 semester, however there was a requirement for the students to do a CBL activity at the end of every lecture, as part of a student group activity. The case study was chosen to incorporate items that were covered during lectures that day, through placing this knowledge learned into perspective in real world environments. The students were required to work in groups to retrieve answers from within the case studies, and then to participate as a group to voice their ideas and findings alongside the other groups in a peer review process. The key findings would later be shown to the students in the form of a PowerPoint presentation to ascertain if any important items were omitted.

<u>Analysis 1: Statistical Overview</u>

(1) The average (mean) assessment outcomes showed a marginal decline of 2,21% with the introduction of the selected learning methods in 2015 (63,76%) in comparison to the computer based syllabus of 2014 (65,97%), however this value was still an improvement on the 58,00% mean assessment result noted in 2013.

(2) The range of assessment results was smaller in 2015 at 76% in comparison to the 2014 values of 82%, placing this value back at the range noted in 2013 (76%).

(3) The average deviation in the assessment results was lower in 2015 at 13,43% in comparison to the 2014 values of 16,24%, but marginally larger than the 2013 figures of 12,85%.

(4) The skewness of the assessment results again provided a negative value in 2015, this time coming in at -0,190, slightly down from the 2014 value of -0,282, which differed from the positive skew of 0,247 noted in 2013.

STATISTIC	2013 (paper based) S4	2014 (computer based) S4	2015 (learning methods) S4
Frequency	249	235	300
Mean results	58,00 %	65,97 %	63,76 %
Average deviation	12,85 %	16,24 %	13,43 %
Skewness of results	0,247	-0,282	-0,190
Range of results	76%	82 %	76 %
Average experience rating	11,06	17,41	9,33
% per experience point	5,24	3,79	6,83

Figure 63: Table - Statistical Analysis Comparison

2013 (paper based) to 2015 (CBT & learning methods introduction)

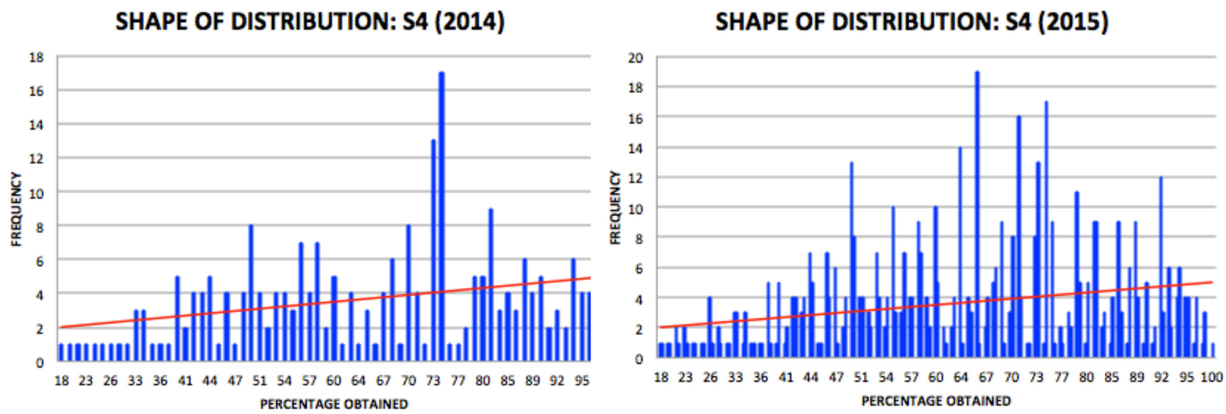

Figure 64: Graph - Shape of Distribution of assessment Results 2014 (computer based) to 2015 (learning methods introduction)

Statistical significance: Comparing the 2014 and 2015 results, the calculated t-value of 3,8 was greater than the calculated critical t-value of 1,65 (assuming a confidence level of 95%). This could indicate that the differences between the 2014 and 2105 results can be considered to be statistically significant, and not as result of random sampling error. Comparing the 2013 and 2015 results, the calculated t-value of -4,4 was greater than the critical t-value of 1,65; which again shows that the data analysed could be considered to be statistically significant.

Analysis 2: Experience to assessment outcomes correlation factor

The population sample profiles reflected upon those students who had now moved through the system without any prior experience within the maritime industry. Once the assessment and examination results were loaded against each profile, the trend indicated a positive correlation to exist with a Pearson's *r* value[69] of 0,343.

With this positive correlation being at a lower value than the previous studies (despite having low experience levels), the trend indicates an improvement in the outcomes of those students who have lesser experience in relation to their peers.

[69] In statistics, the Pearson product-moment correlation coefficient (Pearson's r) is a measure of linear correlation that exists between two variables X and Y, giving a measure of between (-1) negative correlation and (+1) positive correlation, with (0) being a neutral value.

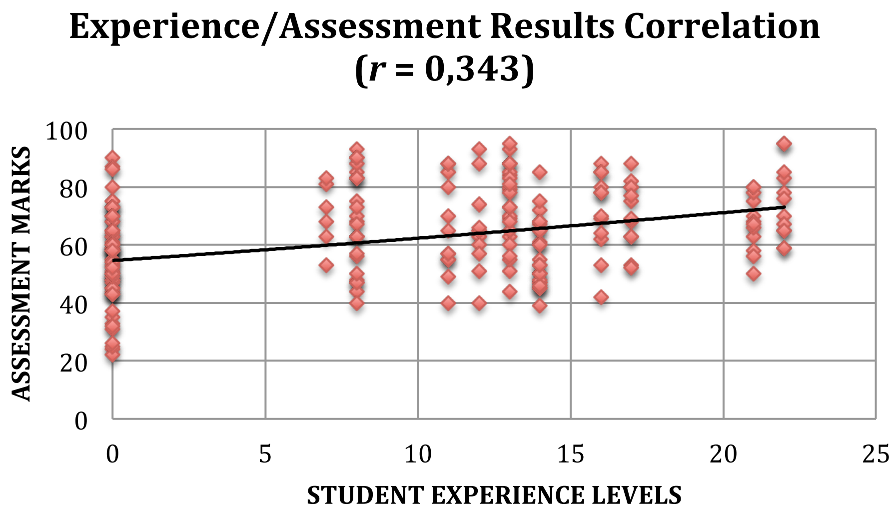

Figure 65: Graph - S4 student analysis survey (semester 2, 2015 – Chief Engineers)

Analysis 3: Proficiency Growth model: (Growth Model 1)

The first comparative growth model used to compare the assessment results over the two systems in use (termed the 'proficiency growth model') tabled and graphed the outcomes on a comparative line chart to see how well the groups of students compared to previous groups that had used a different method of tuition. Due to the successive student groups possessing different academic potentials, the results obtained from this growth model are to be factored into the outcomes from the study in its entirety, once all learning methods have been analysed, and not used as direct outcomes for this phase of the study as a result of this confounding variable.

PROFICIENCY	2013 (paper based) S4	2014 (computer based) S4	2015 (learning methods) S4
Proficiency Rate (50% and above) All Assessments	170 / 249 68,3%	187 / 235 79,6%	242 / 300 80,7%
Proficiency Rate (50% and above) Final Examinations	44 / 83 53,0%	64 / 89 71,9%	60 / 96 62,5%

Figure 66: Table - Written assessment outcomes comparison

2013 (paper based) to 2015 (CBT & learning methods introduction)

The results obtained using the first growth model (proficiency) analysed the 784 assessments that were conducted over the respective six-month periods (2013: 249, 2014: 235 and 2015: 300). These results indicate a consistent increase in the overall assessment pass rate from 2013 (2013: 68,3%, 2014: 79,6% and 2015: 80,7%). Changes noted in the examination pass rate since 2013 show an improvement in 2014 of 18,9% and 2015 of 9,5% compared to 2013 levels.

Analysis 4: Performance Index Model: (Growth Model 2)

The second growth model was used to analyse the assessment outcomes (termed the ‘performance index model’) categorised the results obtained into percentage groups in order to view the groups in context between successive semesters. The performance index model used assessed the outcomes from the final written examinations only, due to the fact that each individual paper is externally moderated by SAMSA. Over the periods under review, a total of 268 examination results were assessed (2013: 83 data points, 2014: 89 data points and 2015: 96 data points). The outcomes of the 268 data points assessed over the course of these three periods under review, have been categorised as follows:

- 1st category: This category comprised those candidates that were found to not yet be proficient in terms of the assessment outcomes. This group included all of the candidates that achieved a mark below 40% the final written examination for each of the subjects.

- 2nd category: This category comprised those candidates that were required to sit a second supplementary exam for re-assessment purposes. This group included all of those candidates that achieved a mark in the 40% to 49% range for a particular final written examination for any of the subjects.
- 3rd category: This category comprised those candidates that were found to have achieved proficiency in the particular subject final examination, but fell below the threshold required in order to be awarded a distinction for the final examination. This group includes those candidates that achieved a result of 50% and above, but below the 75% required for the distinction, for the final written examination for any of the subjects.
- 4th category: This category comprised those candidates that achieved a distinction. This group of students included those that have been awarded a mark of 75% or above for the final written examination for any of the subjects.

Again, the confounding variable associated with different student groups exists, however it is the intention to place the findings in perspective amongst the spread of results obtained, to ascertain whether or not a positive impact has been registered in any particular category.

Examination Results	2013 (paper based) S4	2014 (computer based) S4	2015 (learning methods) S4
Below Basic (39% or less)	12,0 %	10,1 %	10,4 %
Basic (40% to 49%)	34,9 %	14,6 %	27,1 %
Proficient (50% to 74%)	47,0 %	41,6 %	54,2 %
Distinction (75% and above)	6,0 %	30,3 %	8,3 %

Figure 67: Table - Written examination outcomes comparison

2013 (paper based) to 2015 (CBT & learning methods introduction)

Over this period, the student examination failure rate improved marginally from 12,0% in 2013, to 10,1% in 2014 and 10,4% in 2015). The student numbers that scored in the 40% to 49% range (those that were required to sit a second supplementary examination) improved from 34,9% in 2013 to 14,6% in 2014, before declining to 27,1% in 2015. The proficiency category (which represents those students scoring above 50%, but below the distinction mark of 75%) dropped from 47% in 2013 to 41,6% in 2014, before improving to 54,2% in 2015. The distinction candidate numbers showed a vast improvement from 6,0% in 2013 to 30,3% in 2014, before declining significantly back to 8,3% in 2015.

Due to the different student dynamics from year to year, the performance index measurement results are to be considered only as a factor when reviewing the outcomes of the change to a digital syllabus holistically.

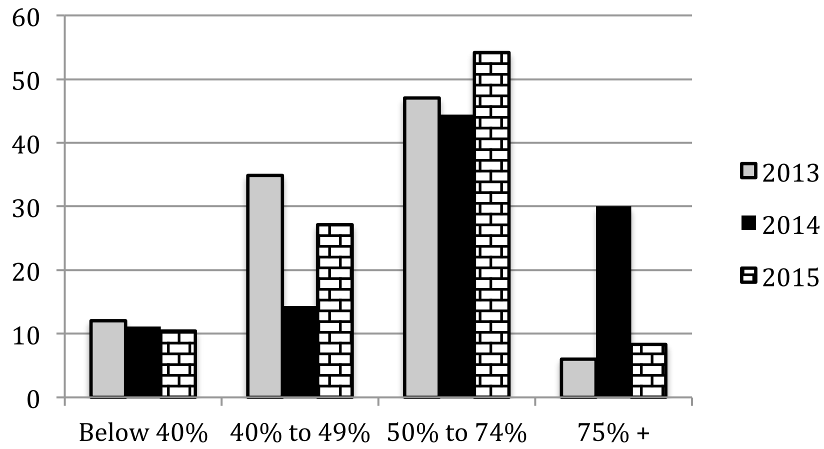

Figure 68: Chart - Performance outcomes within the different categories

Final written examination results: 2013 to 2015

Analysis 5: Simple Growth Model: Growth Model 3

The simple growth model has been used to track the same students who have been studying at CPUT for two successive semesters, and have thus covered the respective syllabi in both paper-based format in the first semester and the digital format in the second semester. The results will be tabled at Chief Engineering Officer level (S4), against those obtained at Second Engineering Officer level (S3), and will be used for comparative purposes alongside a variable that has been established to determine a standard alteration in results between the two successive study levels among the rest of the S4 students. In this way, the students included in this model can be viewed against those students who have not served successive semesters.

This index was selected as a data collection tool as it discounted the confounding variable associated with the previous two growth models, namely that of the different student groups being analysed. The downside associated with the use of the simple growth model in this case is that there are very few students that complete successive semester studies. The total number of student analysed using this model in 2015 was 13, which brings the total cumulative comparison total to 32 students (12 students in 2013, 7 students in 2014 and 13 students in 2015).

Owing to the fact that it is the same students measured, the index more clearly represents a measurement of the learning method used over the course of the study.

A sum total of 732 data points were analysed between 2013 and 2015, with each data point representing one written assessment of one written examination (2013: 224, 2014: 144 and 2015: 364). In 2015 the marks increased from the semester before, registering an improvement overall of 1,47%. This result is in contrast to the declines noted in 2013 (- 4,99%) and 2014 (- 5,03%).

In terms of the final written examinations, a total of 310 data points were analysed (2013: 85, 2014: 69 and 2015: 156). These results showed a further drop from a 4,81% decrease noted in 2013 and the 5,38% decrease noted in 2014, to register a value of -7,35%.

PAPER SYLLABUS vs. DIGITAL SYLLABUS				DIGITAL SYLLABUS vs. LEARNING METHODS			
STUDENT	S3 (2014)	S4 (2014)	CHANGE	STUDENT	S3 (2015)	S4 (2015)	CHANGE
Student 9	66,58 %	63,08 %	- 3,50 %	Student 15	63,25 %	63,08 %	- 0,17 %
Student 10	73,25 %	68,00 %	- 5,25 %	Student 16	57,75 %	65,92 %	8,17 %
Student 11	51,42 %	53,08 %	+ 1,66 %	Student 17	61,31 %	60,17 %	- 1,14 %
Student 12	49,50 %	40,50 %	- 9,00 %	Student 18	49,13 %	57,33 %	8,21 %
Student 13	64,58 %	58,33 %	- 6,25 %	Student 19	64,88 %	53,42 %	- 11,46 %
Student 14	57,92 %	50,08 %	- 7,84 %	Student 20	57,88 %	61,08 %	3,21 %
				Student 21	67,63 %	61,00 %	- 6,63 %
				Student 22	62,56 %	69,58 %	7,02 %
				Student 23	60,13 %	56,82 %	-3,32 %
				Student 24	69,94 %	70,83 %	0,89 %
				Student 25	50,38 %	56,75 %	6,38 %
				Student 26	51,88 %	58,42 %	6,54 %
				Student 27	82,94%	84,33 %	1,40%
AVERAGE CHANGE			- 5,03 %	AVERAGE CHANGE			1,47 %

Figure 69: Table - Written assessment & examination outcomes comparison

2013 and 2014 Comparisons using the Simple Growth Model

7.4.2 Research sub-question 2: Blooms taxonomy assessments analysis

Analysis 6: Blooms revised taxonomy review

The General Engineering Knowledge subject assessments for this semester were set to cover levels one to five of the Blooms revised taxonomy model, as again level 6 (the creation of knowledge) was deemed to fall outside of the requirements of a diploma program. Assessments were designed from the outset to cover these disciplines within the model to varying extents, which were to be categorised upon completion. This was to be done to provide an indication of the level of understanding that took place. A sum total of 48 data points were analysed, which represented the total of assessments written for that particular subject. Of this total, 24 assessments were graded at the beginning of the semester (1st assessment) and 24 were graded towards the end of the semester (2nd assessment). The results from these findings are listed below.

With both assessments taken into account, the lower order skills component (comprising the remembering and understanding skill sets) scored class mean values of 66,3% and 47,4% accordingly. The mid-level components of application and analysis achieved mean values of 71,5% and 76,3% respectively, whilst the higher order skill set of evaluation achieved 54,3%.

(i) Level1 - Remembering (66,3%): Questions from this level of the Blooms revised taxonomy model comprised 20,0% of the total questions asked (20,0% in the first assessment, and 20,0% in the second assessment). The mean mark obtained over the two assessments was one of only two layers within the revised taxonomy model that recorded a result of over 50%, which is the subject pass.

(ii) Level 2 – Understanding (47,4%): Questions from this level of the Blooms revised taxonomy model comprised 22,5% of the total questions asked (22,5% in the first assessment and 22,5% in the second semester). This drop in percentage value from the pure recall of subject knowledge is in line with how the lesser-experienced students will naturally be challenged when the knowledge recalled has to be placed in perspective and understood. The mark obtained from the understanding portion within the revised taxonomy model was marginally above the 50% pass required of the subject.

(iii) Level 3 – Application (71,5%): Questions from this level of the Blooms revised taxonomy model comprised 22,5% of the total questions asked (22,5% in the first assessment and 22,5% in the second assessment). These questions related to practical tasks that were required to be carried out onboard a ship. The mark obtained from the application portion within the revised taxonomy model was well above the 50% pass required of the subject, showing an improvement in terms of the application of knowledge over the last S4 study phase.

(iv) Level 4 – Analysis (76,3%): Questions from this level of the Blooms revised taxonomy model comprised 20,0% of the total questions asked (20,0% in the first assessment and 20,0% in the second assessment). The mark obtained from the analysis portion within the revised taxonomy model was well above the 50% pass required of the subject. Results obtained from this section represented the highest marks obtained from within the six categories of the model, in comparison to this group scoring the least at the S4 level from the previous phase of the study.

(v) Level 5 – Evaluation (54,3%): Questions from this level of the Blooms revised taxonomy model comprised 15,0% of the total questions asked (15,0% in the first assessment and 15,0% in the second assessment). These questions related to the students being given certain systems where they were required to identify or explain certain faults that were indicated. The format of the questions represented certain scenarios whereby junior engineers onboard reported to them as senior engineers certain faults that they have identified. It then became the requirement to fault-find, identify causes and provide possible solutions. Again, the results obtained from this segment indicate (in part) a lack of seagoing practical knowledge in many cases. The mark obtained from the evaluation portion within the revised taxonomy model was marginally above the 50% pass required of the subject.

(vi) Level 6 – Creating. In line with keeping the level of questioning at a level of a diploma programme, and to satisfy the requirements of the external moderation process held at SAMSA, questions asked fell outside of the top level of the Blooms revised taxonomy model.

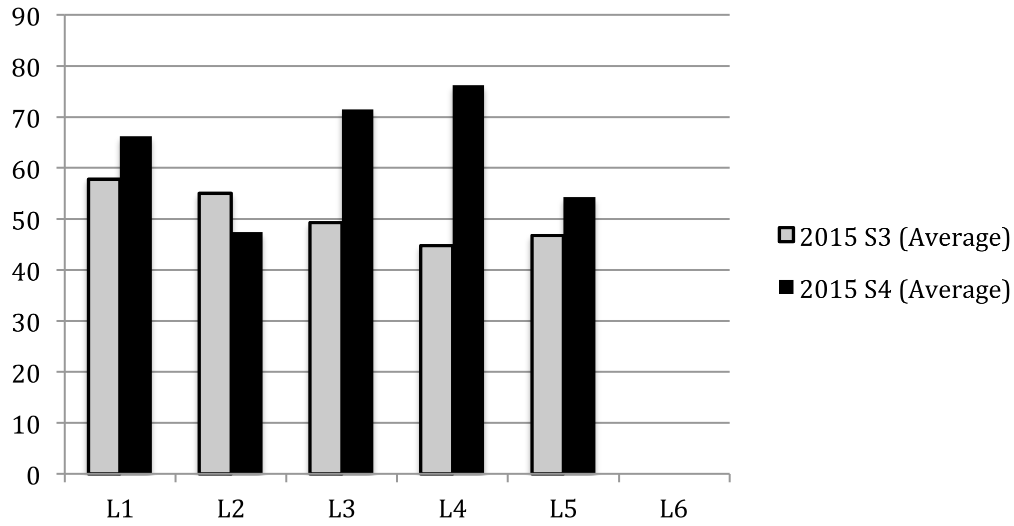

Figure 70: Table - Blooms Taxonomy outcomes comparison

Changes from 2014 to 2015 (the introduction of selected learning methods)

When comparing the differences between the 2014 student outcomes within the various groups to that found in 2015, improvements were noted at the higher levels of the Bloom's taxonomy scale (the application, analysis and evaluation of the subject knowledge).

7.4.3 Research sub-question 3: Methods Analysis

The final data collection survey was conducted at the end of this stage of the study (survey 4), to gather and analyse data regarding how well the introduction of the selected learning methods were perceived by the students within the group. In total, 13 surveys were received from the 18 distributed within the class, from which information was retrieved with regards to the following key points:

(i) Peer interaction (GBL): The students were required to state to what extent the believed that working in groups with their peers aided their understanding of the subject matter. The option for this choice was between (i) not much assistance (ii) a fair amount of help (iii) a lot of assistance and (iv) completely helped them to understand the work.

(ii) Items of importance (CBL): The second survey question asked the students to choose between which of the following items (named, rank order) were responsible for aiding their studies in light of there being no practical component associated with the course: (i) case studies of past accidents and shipping casualties (ii) The addition of photographs from actual South African ships to the course material (iii) The inclusion of more material from manufacturer's technical manuals and (iv) The inclusion of manufacturer's product brochures. If the students felt that two ore more categories within the group carried equal weight, they were free to grade those items equally.

(ii) Volume of information: The third survey question again asked the students to choose between the following two questions:

(a) "The amount of work was too much, my main aim was to learn just what is required to pass the assessments"
or

(b) "I used all of the information provided to try and understand the subject material the best that I could".

The reasoning behind this was to ascertain the degree of information overload as perceived by the students, and to determine to what degree the CBT media files were used to complement the text component of the course.

(iv) Help to Marine Engineers at the operations level: The final survey question asked the students (now that they have worked with concept mapping for a year), to state their opinion regarding how well a CBT program can aid students who have never been to sea before, given the time frame with which the course is conducted. The choices for this question were: (i) CBT programs are not really much help (ii) CBT programs are of limited help (iii) CBT programs are a lot of help and (iv) CBT programs can completely help students who have never been to sea before.

Research Question 3: Constructionist design and scaffolding elements analysis

The findings from this survey have been documented in the table below. In each case, totals that do not add up to 13 are as a result of omitted survey information.

CBT Constructionist Design Elements (Scaffolding)		
Information Overload	Information overload, assessment pass prioritised	Resources utilised, deeper understanding prioritised
	4	9

Figure 71: Table – Scaffold design analysis of devised CBT model

9 of the 13 survey respondents stated that they used all the material they could to deepen their understanding of the subject matter, whilst 4 stated that the volume of information was too much for them to cope with, and that their sole focus was on passing the assessments. This was an improvement on the S3 group the semester before, most likely as a result of the students at this level having a better idea of the volume of knowledge required of a Marine Engineer at the management level.

Research Question 3: Analysis of selected learning methods

(a) Group-based learning

The question asked in the survey attempted to illicit feedback with regards to student perceptions about the social learning aspects of GBL. The results of this question posed within the survey are as follows:

Learning Methods Perception Analysis (Group Based Learning)				
To what extent did GBL aid your understanding of the subject matter?	Not much	A fair amount	A lot	Completely
	1	5	4	2

Figure 72: Table – Learning methods perception analysis (GBL)

Looking at the outcomes from this survey, there was generally a positive feeling towards how GBL impacted of the students' ability to better understand the subject matter, with only one of those surveyed stating that GBL had no effect in terms of their subject understanding. One survey question among those returned was unanswered.

(b) Case-based learning

Learning Methods Perception Analysis (Group Based Learning)				
List the following items in terms of preference (ability to compensate for a lack of practical course content)	Case studies of past accidents and shipping casualties	The addition of photographs from actual South African ships to the course content	The inclusion of more material from manufacturers technical manuals	The inclusion of manufacturers product brochures
	24/52	30/52	28/52	41/52

Figure 73: Table – Learning methods perception analysis (CBL)

The results were scored according to a Likert scale, with a within a maximum possible value of 52 points (13 surveys x 4 categories). The smallest value scored within the group being regarded as the most important category within the group. The lowest scoring (and thus most important factor in terms of the grading) was the addition of case studies and past accident reports. The second in order of preference was the inclusion of more materials from manufacturers manuals, the third most important being stated as being photographs from South African ships, and the least important being manufacturers product brochures,

Research Question 3: Thinking and learning style analysis

Analysis of the thinking and learning styles catered for during this phase of the study primarily focused on the form that the various assignment maps that were constructed in line with Stenberg's thinking style model and Kolb's learning style model (section 2.3).

After the completion of the 80 assignment maps that were devised in a format that could cover the range of thinking and learning styles described, and after having participated in the case-studies provided as part of the course, a simple question was asked within the survey as to the ability of these types of exercises to aid students who had never been to sea before. The results to this question are tabled below:

Assignment Map Design Elements (Thinking and Learning Styles)				
Can a CBT program assist those students who have never been to sea before?	Not really	Limited Help	A Lot of Help	Completely
	0	0	9	4

Figure 74: Table - Thinking and learning style analysis of devised CBT model

In terms of whether or not a CBT model of Marine Engineering education has the ability to 'make up' for a lack of prior experience on the part of many of the students, the consensus was more positive than the preceding S3 student group. It was felt that the the assignment map designs (procedure-based, sequence-based etc.) and participative case studies could be of benefit to those who have never been to sea before, with no indication being provided to the contrary. 69% of the respondents felt that a CBT model would go a long way to compensate for a lack of prior industry exposure, and the remaining 31% felt that a CBT model could completely make up for a lack of prior industry experience.

Summary

From the open ended questions that were part of the survey, the feedback received and concerns raised are out of the control of CPUT, primarily due to the location (ship visits), resource and space constraints (practical model usage), time constraints (simulator use and video's) and from factors that are not possible (removal of course content), which is a code requirement.

7.5 Peer review of examination standard

The final survey was conducted in two formats in order to ascertain the perceived General Engineering Knowledge examination difficulty levels over the past three years, as judged by professional peers within the industry. A total of 9 surveys were sent out via Email to serving Chief Engineers within the industry, and all 9 Chief

Engineers responded. Another 4 surveys were received from Chief Engineers that were completed by them at the CPUT DMS. In addition to these surveys, appointments were set up with two SAMSA senior examiners for the purposes of obtaining their surveyed data. One of these meetings was held at the CPUT DMS and the other at the SAMSA offices in Cape Town between February and May 2016. The two senior examiners represented both the past and present senior examiners that have held the position for roughly the last decade. The responses obtained via both formats have been tabled together.

The dates were removed from each of the attached examination papers, and replaced with either X, Y or Z so that the survey participants were unaware of what year the papers were written.

Those papers that were considered to be the easiest were graded 1 point, the middle papers were graded 2 points and the most difficult of the three were graded 3 points. From the 15 survey responses that were received, each paper could possibly score a maximum difficulty rating of 45 points. The 2013 paper (paper based syllabus) was termed paper X, the 2014 paper (computer-aided syllabus) was termed paper Y and the 2015 paper (the introduction of the chosen learning methods) was termed paper Z.

The responses from the population sample for this particular survey were as follows, with the X, Y or Z surveyed answer replaced by the year in which the paper was formulated:

No.	Qualification	Nationality	Location	Easiest	Middle	Most Difficult
1	Chief Engineer	S. African	Australia	2014	2013	2015
2	Chief Engineer	S. African	S. Africa	2014	2015	2013
3	Chief Engineer	Mauritian	Mauritius	2014	2013	2015
4	Chief Engineer	S. African	Brazil	2013	2014	2015
5	Chief Engineer	Angolan	Angola	2014	2013	2015
6	Chief Engineer	Angolan	Angola	2013	2014	2015
7	Chief Engineer	S. African	Asia	2014	2013	2015
8	Chief Engineer	S. African	Brazil	2015	2013	2014
9	Chief Engineer	S. African	Unknown	2013	2014	2015
10	Chief Engineer	S. African	UAE	2014	2013	2015
11	Ex-Senior Examiner (SAMSA) 2002 - 2014	S. African	S. Africa	2014	2013	2015
12	Current Senior Examiner (SAMSA) 2014 -	S. African	S. Africa	2014	2015	2013
13	Chief Engineer	S. African	UAE	2015	2013	2014
14	Chief Engineer	S. African	Unknown	2013	2015	2014
15	Chief Engineer	S. African	Unknown	2013	2014	2015

Figure 75: Table - Peer review of examination standard – Gen. Engineering Knowledge

2013 (paper-based), 2014 (computer-based) & 2015 (learning methods)

The results from the survey indicate that the participants viewed the 2013 and 2014 papers as being equally difficult, but easier than the 2015 examination. The grading allocated according to the scale devised totaled 25 out of a possible 45 for both of these years. The paper that was judged to be the most difficult of the three was the 2015 paper, which scored a total of 38 out of a maximum 45.

A summary of the quantitative analysis findings from each phase of the eighteen-month study are viewed in conjunction with the outcomes from this particular survey in the section that follows.

7.6 Data analysis summary

The table that follows summarises the key findings with relation to comparable outcomes noted at each phase of the study, according to the following guidelines:

(a) S3 level: 2014 (computer-aided) compared to 2013 (paper-based).

(b) S4 level: 2014 (computer-based) compared to 2013 (paper-based).

(c) S4 level: 2015 (computer based + learning methods) compared to 2013 (paper-based).

FINDING	Computer-based (S4)	Computer-aided (S3)	Learning methods (S4)
Mean Results	Better by: 7,97 %	Better by: 1,24 %	Better by: 5,76 %
[Exam] Failure Rate	Better by: 1,9 %	Better by: 0,6 %	Better by: 1,6 %
[Exam] Require Re-assessment	Better by: 20,3 %	Better by: 3,2 %	Better by: 7,8 %
[Exam] Pass Rate (Distinction)	Better by: 24,3 %	Better by: 7,9 %	Better by: 2,3 %
Statistical Significance [Y/N ?]	Yes	No	Yes
Blooms Taxonomy Trend Notable [Y/N ?]	n/a	No	Yes
Same Student Monitoring [Improvement Y/N ?]	No	No	Yes

Figure 76: Table - Key quantitative analysis findings with regards to academic outcomes 2013 to 2015

7.7 Contributing factors

The findings with respect to the data analysed need to be viewed alongside any factors that may have impacted the results over the eighteen month data collection phase. These factors can be listed as follows:

(i) Subject contents: Over the eighteen-month data collection phase, the same subject content was used for the delivery of the course syllabi for each successive six-month phase, with the material being compiled before the start of this particular study. The content has been formulated in accordance with the SAMSA code governing the delivery of a Marine Engineering curriculum, in line with the institutional accreditation process for the CPUT DMS.

(ii) Leadership: No changes were made with regards to the subject lecturer during the duration of this study, with no other lecturers being involved with the delivery of the subject content. This is in line with the SAMSA accreditation process for approval of the lecturer to deliver classes at a management level.

(iii) School and student culture: Whilst no changes were made to method with which maritime studies were conducted at the CPUT DMS during this study, talk about the proposed changes to the future Bachelor of Marine Engineering degree programme in 2018 has been ever present on the part of the students. In this regard, certain students may have taken the decision to remain within the current system to complete their S4 level (and obtain their diploma), before these changes come into effect. These changes would likely require those students wishing to build upon their current qualifications to do so at one of the TVET colleges that are still to formulate Marine Engineering programmes at a diploma level.

(iv) Adaptability to new approaches: In contrast to the findings at the SMA (Chatterjea & Nakazawa, 2008), results from the survey conducted (survey 3) at the S3 level showed that the more senior students (S4) adapted easier to the introduction of computers than did the S3 students. Whilst the drive to embrace technology gathers pace at higher educational institutions, the lack of computer use at secondary school level for the majority of the students meant that there was a certain degree of unfamiliarity with computer use among this group.

(v) Budget: During the course of this study, no changes were made to the Marine Engineering budget allocation, nor were there any changes made to classroom resources or available materials.

(vi) Political landscape: Perhaps the biggest environmental factor to impact this study came about as a result of the #FeesMustFall nationwide student protest action against tuition fees. This protest action resulted in one week of lost classroom time (although the lectures for the subjects covered within this study were completed by this time), and a postponement of the final examinations. This is believed to have an impact on the examination results for this phase across the board (i.e. 7% mean decrease in examination results for the S2 Chart work subject[70] over the previous year). While this is mentioned as a factor within this study, quantifying the outcomes of this protest action specifically falls outside the scope of this study.

Summary

Upon collection and analysis of the data, and with an understanding of the outcomes associated with introducing computer-based learning in a developing country, with the aim of compensating for practical resources that are lacking, the findings can be summarised in the chapter that follows.

[70] Data retrieved from MAS results by Leonie Louw-November (Chart work lecturer) January 2017.

CHAPTER 8

DISCUSSION: CONCLUSION AND RECOMMENDATIONS

Introduction

This case study involved three different groups of students studying at a senior level within the Marine Engineering discipline at a South Africa University of Technology, and was conducted within a classroom environment over three successive six-month semesters using an action research method. After the initial data collection surveys were conducted in order to gain insight as to the student dynamics and the environment, the entire Marine Engineering syllabus was mapped out using CMapTools open-source concept mapping software. This CBT model was based on scaffold principles, and incorporated a range of selected learning methods that were based on prominent learning theories, in order to address the identifiable shortcomings that existed with a paper-based model of education. Joseph Novak, who is widely regarded as being the originator of concept mapping, believed that the lack of available resources in a developing country could largely be obviated by the use of emerging technologies. However, prior to this study, little had been done in terms of testing the viability of that belief over an extended timeframe, within the setting of a developing country environment.

Data was collected at each phase of the study, and profiles were compiled that represented both the individual experience levels and the English language capabilities of the students. The results obtained from the written assessments and examinations that followed were loaded against each profile as the semester progressed in order to ascertain what impact the change to a CBT model of education would have on learning outcomes. The findings from this study are to be noted against the literature from which the learning methods were derived (in accordance with the prominent learning theories), as well as against those obtained during a shorter duration course conducted within a developed country (the Singapore Maritime Academy).

8.1 Summary of this study

Chapter 1 introduced some of the challenges that South Africa is facing with regards to the poor state of secondary school education in the country, and the repercussions that this standard has on institutions of higher learning. Within the maritime sector, the challenges facing MET institutions with regards to the country being a developing maritime nation were also introduced. With a lack of available ships onto which cadets can be placed, and without many of the practical maritime resources that other developed countries enjoy, South African seafarers are limited with regards to practical seagoing and shipping related exposure at the time of commencing their academic studies. These points provided the motivation for this study, with the culmination of this chapter outlining the intended contribution that this study aims to make.

Chapter 2 of this study looked at learning methods that could be used to form the basis for introducing a computer-based model of education aimed at compensating for the practical resources that are lacking within the maritime industry in South Africa. The learning theories of constructivism (Lev Vygotsky, Jean Piaget), constructionism (Seymour Papert) and social learning theory (Albert Bandura) were detailed, along with motivation of why these more traditional learning theories were selected for this study, over more contemporary alternatives. The design of the model introduced was intended to retain a fluidity that could allow for the students to adapt the computer-based model towards their individual learning and thinking style preferences. The learning and thinking style models of David Kolb and Robert Sternberg respectively were selected for this purpose.

Methods to suitably ascertain the effectiveness of the developed methods introduced (based on the chosen learning theories), necessitated a review be conducted of the Bloom's revised taxonomy scale, and the chosen methods themselves. The chapter concluded with a review of the English language ability of the population sample, and the impact that this may have when the group based learning phase of the study is introduced.

Chapter 3 looked at the prominent computer based models that are available, with a view towards selecting an appropriate model for use that can work within the constraints found within a developing country. Various online learning management systems were reviewed, alongside an open-source concept-mapping alternative CMapTools that meet the needs of both the institution, and that of the students. The requirements in terms of the hardware and software that was needed to introduce the computer-based model was investigated, after which the requirements that could allow for distance learning for seafarer education were outlined.

Chapter 4 reviewed what the various MET institutions within South Africa were doing with regards to technology usage, as well as looking at a study that had previously been conducted at the Singapore Maritime Academy using concept mapping. Included in this chapter was feedback that had been received from maritime industry role players within South Africa, including representatives from the South African Maritime Safety Authority, as to their view on the state of seafarer education in South Africa.

Chapter 5 explained the method used by which the data was collected and analysed. This section introduced the research questions that had been formulated and explained the chosen research paradigm of interpretivism. The reasoning behind the choice of single case study research using an action research methodology was explained, along with the action taken in order to minimise the bias that presents itself within this environment. The chapter concluded by looking at the research participants, the research instrument and the limitations associated with a study of this nature.

Chapter 6 explained in depth how the information received from the initial round of data collected was used to formulate a computer-based model that could work in the particular environment. A discussion of the environment explained the challenges facing many students with regards to computer literacy, and their ability to embrace the introduction of classroom technology. A contextualised choice of the chosen computer based model followed, along with descriptions of how the model evolved during the course of the study, in line with the action research process, in order to suitably test each research sub-question.

Chapter 7 explained how the data analysis was done at each stage to assess if there was any notable change with regards to improvements in academic outcomes. The peer review of the examination standard that followed this process was formulated to further reduce bias by allowing for an independent evaluation of comparative examination standards from Class 1 Chief Engineers (peers) within the industry. The chapter concluded by outlining the various environmental factors that may have contributed to or impacted on the noted research findings from the study.

8.2 Discussion

Before looking at the contributions this study can make to both literature and practice, the notable findings from each of the research sub-questions are explained. After listing these findings, a discussion will follow with regards to how these finding align themselves to comparative studies of a similar nature. These include (a) studies about the introduction of concept mapping for education purposes in a developing African country, (b) the introduction of computer-based concept mapping in a maritime domain within a developed country, and (c) how the students managed the change to computer-based studies.

The research sub-questions fall under the umbrella of the main research question, which is:

> "*Could technology be used to counter a lack of available resources, in order to improve the academic outcomes of Marine Engineering students in South Africa?*"

In order to answer this research question, each research sub-question was tested over a six-month period (academic semester). The results obtained from these tests are described in the section that follows.

Research sub-question 1 (first semester)

By adopting a purely paper-based method of tuition as opposed to the purely computer-based method of tuition that previously existed, would there be any notable improvements in student learning outcomes among the research participants?

Data analysis results that were obtained from this semester indicated that statistical improvements were noted in both the mean assessment marks, and the shape of the assessment marks distributions with the introduction of classroom technology. These outcomes indicated that the results could be considered to be statistically significant through a comparison of the results obtained before and after the introduction of classroom technology. Improvements were also noted in terms of student pass rates, reduced number of failure rates, a reduction in borderline student numbers (those requiring a supplementary examination), and there was a notable increase in the number of distinction candidates. Despite these improvements, the index that was used to track the same students through successive semesters showed no notable change among these candidates in favour of migration towards a computer-based method of tuition. This finding however was obtained from a very small sample size of six students, as this represented the number of students who attended successive semesters (S3 and S4) back-to-back.

Qualitative participant feedback that was obtained from the population sample noted improvements with regards to enhanced information retrieval and planning aspects in favour of the change, however it was mentioned that the computer-based method in use resulted in the students making less use of external sources of information. The general consensus was that the CBT model implemented was more engaging than the paper-based syllabus used previously.

These findings would be in agreement with both the research sub-question and the research question, and in agreement with the beliefs of Joseph Novak. The notable outcomes are in line with the initial expectations.

Research sub-question 2

If the CBT model were tailored to work in conjunction with existing paper-based literature in order to enhance the understandability of the texts, would there be any notable change in terms of academic outcomes among the research participants?

Data analysis of the outcomes of the lower level management students showed minimal (yet positive) change in terms of mean assessment results with the introduction of classroom technology (computer-aided learning), with the shape of the assessment marks distributions indicating a negative trend to that obtained previously.

The statistical significance test that was conducted on the results of this group, that compared the two models (paper vs. computer aided study) did not produce any indication of statistical significance, and may therefore indicate random sampling error. The pass rates marginally declined over the duration of this semester, despite there being improvements noted with regards to subject failures (reduced), borderline-student numbers (reduced) and the number of distinction candidates (increased).

The Blooms taxonomy analysis that was conducted over this period showed that the lower level management students were, in general, unable to demonstrate any improvement in higher order skills such as understanding, application and evaluation of knowledge.

Qualitative feedback that was received from these participants indicated a preference towards books and paper as opposed to computer-based methods of tuition. Although this group stated that they believed a CBT model could aid their understanding, there was not enough evidence to back this up.

The data that was analysed from this group did show marginal improvements in general, despite not being regarded as statistically significant. As a result of a lack of statistical significance being observed, and no notable change in the assessments set according to the Bloom's taxonomy scale, the change cannot be considered to be a notable improvement.

Therefore, although the results obtained were more positive than those obtained previously, the findings do not wholeheartedly answer in favour of the research question or the beliefs of Joseph Novak. Additionally, the findings contrast those obtained from the study conducted previously at the SMA, in that the lower level students (younger) fared worse than their higher level (older) counterparts. The notable outcomes are not in line with the initial expectations.

Research sub-question 3

Would incorporating learning methods based on prominent learning theories, that have been specifically developed in order to address the identifiable challenges that exist, have any significant impact in terms of learning outcomes among the research participants?

An improvement was noted in terms of the mean assessment outcomes in comparison to the paper-based syllabus, despite declining experience levels over this period. The shape of the distribution results again showing a negative trend. A test conducted for statistical significance again produced positive results in favour of the change, similar to the previous group of S4 students. Data analysis that was conducted showed an improvement in terms of overall pass rates, a reduced number of subject failures, a reduction in the number of borderline-students numbers (those requiring a supplementary examination), and a marginal increase in the number of distinction candidates when compared to a paper-based syllabus.

The index that was used to track the same students through successive semesters, showed a distinct positive change over the course of this semester, from a sample size of thirteen students.

The Blooms taxonomy analysis that was conducted indicated improvements in higher order thinking skills among this group. The levels of understanding, application and evaluation of knowledge reflect positively on the introduction of learning methods into the computer-based curriculum.

Qualitative participant feedback obtained showed that the general consensus was that the CBT model implemented was more engaging than a paper-based syllabus, with the senior management students believing it to have the ability to aid students who had never been to sea before.

Summary

The key findings with regards to quantitative analysis are listed in the table below.

FINDING	1st SEMESTER Computer-based[71] (S4)	2nd SEMESTER Computer-aided[72] (S3)	3rd SEMESTER Learning methods[73] (S4)
Mean Results	Better by: 7,97 %	Better by: 1,24 %	Better by: 5,76 %
[Exam] Failure Rate	Better by: 1,9 %	Better by: 0,6 %	Better by: 1,6 %
[Exam] Require Re-assessment	Better by: 20,3 %	Better by: 3,2 %	Better by: 7,8 %
[Exam] Pass Rate (Distinction)	Better by: 24,3 %	Better by: 7,9 %	Better by: 2,3 %
Statistical Significance [Y/N ?]	Yes	No	Yes
Blooms Taxonomy Trend Notable [Y/N ?]	n/a	No	Yes
Same Student Monitoring [Improvement Y/N ?]	No	No	Yes

Figure 77: Table - Key quantitative analysis findings with regards to academic outcomes 2013 to 2015

[71] Computer based refers to study via computer only – students only provided with digital resources.
[72] Computer-aided refers to study with both published literature and digital resources (blended method).
[73] Learning methods refers to the semester where GBL and CBL were included with both published literature and digital resource use.

8.2.1 Outcomes comparison to previous case studies that have been conducted on the introduction of CBT methods in developing countries

The three case studies that have been chosen for comparison[74] with the findings to this CPUT DMS case study are discussed within this section.

(a) The UCSC case study (Sri Lanka) conducted by Andersson in 2008, looked at the impact that the introduction of CBT would have in an environment where it was stated that Sri Lankan students were not (in general) technologically confident. As a result of individual computer-based learning practices being required with the introduction of CBT methods, it was believed that a greater amount of support would be required. The researchers and staff anticipated a higher than normal drop out rate among the students on a distance learning computer-based course when compared to traditional classroom based teaching methods.

Despite greater levels of support being offered to the CPUT DMS students (classroom based CBT methods) as opposed to those offered within the UCSC study (CBT via distance learning), the feedback received from the CPUT DMS study students with regards to support and guidance concurs with those of the UCSC study students.

The UCSC study students felt that they required a greater level of support and face-to-face feedback than was actually afforded to them. Although daily classroom sessions were held at the CPUT DMS, many of the CPUT DMS study students indicated that due to them not being fully comfortable with the use of computers for educational purposes, preference was still given towards the more traditional tuition methods - where they could 'highlight' text and ask questions in real time as required.

With regards to flexibility & access, the UCSC study students found connectivity to be a challenge for many students, therefore making it difficult at times for them to access the content from an internet-based LMS. This particular area

[74] Refer to Chapter 3.1.1 – Sri Lankan, Ghanaian and South African Case studies that looked at the effects that the introduction of CBT methods had in within institutions in these three developing countries.

highlights the benefits of using a resident based concept-mapping platform such as the one implemented at the CPUT DMS, as connectivity issues were largely negated. This form of CBT model demonstrated significant advantages for a developing region that lacks the required infrastructure, while benefitting the less affluent students for whom data transmission is expensive.

It was noted by Anderson (2008) that the use of CBT may be so new to many of the UCSC students that it is '*almost perceived as something unnatural or illegitimate*', regarded as being more akin to mere accessories than tools to get the job done. Findings from this CPUT DMS study concur with those of Anderson with regards to attitudes towards e-learning. At the CPUT DMS, preference is still given by the students towards paper-based or paper/CBT delivery methods, over computer-only tuition methods[75]. Once tabulated, the graphed assessment results from the CPUT DMS study indicate that the weakest students in the group (academically), performed significantly worse when compared to previous years[76], possibly as a result of being hesitant towards the introduction of CBT. The S3 student group, which contains the more junior students among those included for the CPUT DMS study, also had unprecedented dropout rates of 37%. While the factors for this are unknown, it may in part be a result of a hesitancy to adopt a new mode of tuition.

(b) The RUCST case study (Ghana) conducted by Asunka in 2008 noted one of the primary concerns as being that the students were lacking motivation, and were not enthusiastic in any way to embrace independent learning. This was believed to be a result of the RUCST study students proceeding directly from high school, and thus being more used to a didactic teacher-led style of tuition. To manage this, and avoid a possible high dropout rate, traditional design elements were included in the course in an attempt to make the students more comfortable. These methods required greater levels of participation on the part of the student as opposed to allowing for a less-structured free study environment.

75 Refer to figure 60 (table) – Survey data summary.
76 Refer to figure 59 (table) – Survey data summary (failure rates).

Conclusions derived at from the RUCST study included the fact that a blended mode of delivery would likely be more successful (online and face-to-face), as in-class activities could minimise the stress associated with those uncomfortable with online tuition methods. This particular study done at the CPUT DMS would agree with the lack of motivation as being an issue (as mentioned previously), and with that fact that students value collaboration and 'personal contact' over individual and self-directed study methods[77].

(c) The CPUT/UCT/WITS study (South Africa) conducted by Johnston (2013) found that there was a mismatch between the preferences of those of the students to those of the academics when it came to the mode of delivery. The students surveyed indicated that they favour class attendance or demonstrations, followed by a friend showing them, whilst the academics favoured an experimental approach (i.e. do it and see if it works). However, both groups surveyed believed that with regards to CBT systems, that a variety of visual material worked best, favouring a more practical/visual learning style.

While certain of the technological choices and media methods used in the CPUT/UCT/WITS study are not considered for use in this CPUT DMS study (i.e. the use of Facebook as an academic tool, podcasting, YouTube and mobile phone usage), the perception towards the use of computer-based training as found in the CPUT/UCT/WITS study is relevant to this CPUT DMS study. The CPUT/UCT/WITS study noted that a significant difference came to the fore between the students and academics in learning style preference, in that the students sampled preferred demonstrations and discussions with peers, whilst the academics favoured experimentation on the part of the students. Consensus was however reached with regards to the use of computer technology, in that preference was shown towards a visual learning style that incorporates a variety of visual material. It was also shown that the participating students valued the presence of an academic over internet sources

One of the benefits of doing an action research case study such as this CPUT DMS one is that the CBT model developed became a cumulative build process, progressively improving to address the challenges identified. Once all the

[77] Refer to figure 72 (table) – Survey data summary – GBL feedback.

elements were incorporated (i.e. GBL, CBL) the variety of visual content and interaction required catered for an array of learning and thinking style preferences. The results from the final semester indicated that the improvement in academic outcomes can therefore be regarded as being statistically significant in favour of the introduction of CBT. These findings became more notable once the system was afforded the time to develop in line with student feedback that was received. This finding would agree with the CPUT/UCT/WITS study in that although students are immersed in ICT in all aspects of their lives (most often except for study purposes), a change to a system that requires too much individual learning can result in alienation of the students to both education and the academics.

8.2.2 Comparison to similar developing country studies researching the introduction of concept mapping as a tuition method

Whilst the majority of studies involving the introduction of concept mapping in a classroom environment have been conducted in developed countries, two studies that researched the introduction of concept mapping as a tuition method in developing countries are mentioned here. These studies form part of a report compiled by Cañas et al. (2003) on concept mapping in education[78].

Esiobu & Soyibo (1995) tested the effects of concept mapping in different forms of instruction among Nigerian secondary school students, finding that those students using concept mapping greatly outscored those using other methods of instruction. Within this study, the authors cited benefits noted through cooperative learning practices. In another Nigerian study involving secondary school students, Jagede, Alaiyemola & Okebukola (1990) tested whether or not the addition of concept mapping could reduce anxiety, whilst simultaneously improving academic outcomes. The findings from their study showed positive effects to be noted in both anxiety reduction and academic improvements.

Findings from this CPUT DMS study show that the results from the first semester indicate that the outcomes from all of the measured variables were better when concept mapping was used in comparison to the preceding semester(s) when concept

[78] Appendix 2

mapping and technology was not in use. These results were shown to be statistically significant, and not as a result of random sampling error.

With regards to the notable outcomes from the second semester CPUT DMS study group, it was shown that outcomes from the junior management level (S3 students) were not in line with expectations, and not in line with the literature regarding the effectiveness of the introduction of CMapTools at a junior level. Although the results were still marginally positive, it may be concluded that due to a lack of statistical significance, no positive outcomes in terms of the Blooms taxonomy assessment, and no change with regards to the monitoring of the same students, the findings may be a result of random sampling error. The findings from this semester group confirmed that slight positive change has been noted in terms of academic outcomes (research question), yet this change was minimal. The notable outcomes are not in line with the initial expectations.

The final stage of the CPUT DMS study (3rd semester group) indicated an improvement in results at this level, but this time comparing the purely scaffold CBT model used in the first phase to one that make extensive use of the chosen learning methods. These results again indicated statistical significance between the data sets comparing the first and third phases of the study. The findings from both of these semesters confirm that positive change has been noted in terms of academic outcomes (research question) and are in agreement with the beliefs of Joseph Novak. The notable outcomes are in line with the initial expectations.

In summary, the findings from this CPUT DMS study are in line with those of Esiobu & Soyibo (1995) and Jagede, Alaiyemola & Okebukola (1990) in that positive changes in terms of academic outcomes were noted over the duration of the study after the introduction of concept mapping as a tuition method. In the third phase of the study, when learning methods (based on the selected learning theories) were introduced through the concept-mapping platform, the results became more pronounced.

With regards to anxiety level reduction on the part of the students (from both of these studies), this was difficult to ascertain. Concept mapping was introduced in conjunction with computer usage at the CPUT DMS, while both of the Nigerian studies did not use computers. Although this CPUT DMS study did not set out to investigate student anxiety levels, changes to anxiety levels were noted within this study (anxiety levels increased)[79], however this was as a result of the introduction of technology, as opposed to the introduction of concept mapping as a tuition method.

The impact that the introduction of technology had on the students within this study group is described in the section that follows.

8.2.3 Comparison to similar studies researching the introduction of technology, from a computer anxiety perspective

The findings from this CPUT DMS study have been compared to those of two studies that are related. One of the studies looked at the challenges regarding the introduction of digital technology in Africa (Alzouma, 2005), and the other, the introduction of computer-based concept mapping tuition in the maritime domain within a developed country – Singapore (Chatterjea & Nakazawa, 2008)[80].

Alzouma (2005) believes that the vast social divide that exists in many African countries results in inequalities making it challenging with regards to how African populations might be equipped and trained to use information technology, stating *"we should not forget that whatever the technology, its use is shaped by 'external' social conditions. It does not derive from an 'internal' logic commanded by the way the technology has been designed"* (Alzouma, 2005, p.351). As a result of technological resources being unevenly distributed among many African societies, technology can be seen by many disadvantaged students as a tool for the elite to achieve success, becoming an intimidating technology that may ultimately lead to widening the gap (Alzouma, 2005).

Findings from this CPUT DMS study indicate that many of the younger students (S3 group) would agree with those of Alzouma that it can be an intimidating experience. This CPUT DMS study represented the first time that many of the students had used a computer for educational purposes. Qualitative feedback received from this group indicated a preference towards traditional teaching methods, which is a view that differed from the more senior groups, who in general were older and had more experience with computer use.

[79] Survey 3: Preference towards books & paper tuition among this group
[80] Appendix 2

When compared to findings in a developed country, despite the SMA study using a smaller data corpus and having differences in student experience levels, the results indicate that the two studies (CPUT DMS and SMA) share certain commonalities, and one major deviation from the work of Chatterjea and Nakazawa (2008). The outcomes noted disagree with the findings from the SMA study, where it was found that the younger students were more accommodating towards concept-mapping and performed better than the older students, who in general required more assistance.

Students in Singapore are exposed to computer use for educational purposes at a very young age, whereas in South Africa, computer use in secondary schools is still limited. With the greater exposure to computers that the students gained over the course of this CPUT DMS study, especially those students that were monitored over successive semesters (S3 and S4 back-to-back), the more comfortable the students became with the use of computers. This is evident by the feedback received from surveyed data.

8.2.4 How the findings relate to the literature

The scale of this CPUT DMS study has been significantly larger and of longer duration than other known studies to date[81] when looking at the effectiveness of concept mapping and emerging technologies to improve student learning outcomes. The findings overall do answer positively in favour of the research question, and are in agreement with Novak's belief that emerging technologies can be used to compensate for a lack of resources in developing countries (Novak, 2004).

The learning methods introduced were based on selected prominent learning theories, were incorporated into the CBT model in order to address the identifiable challenges that existed (through surveyed data collected at the CBT design phase). The design relied heavily on constructivist design elements that allowed for support (and fading) to compile the syllabi. GBL and CBL were chosen to develop learning methods, and implemented in an attempt to determine if a more thorough level of understanding could be noted in student academic outcomes.

[81] Appendix 2

Jean Piaget believed that constructivism has the ability to aid students in the construction of new knowledge from experiences (Forrester & Jantzie, 1998), with Seymour Papert believing that though constructionism, the learning process takes place with the externalisation (sharing) of this constructed knowledge (Papert & Harel, 1991). Through the monitoring of assessment questions compiled according to the Blooms taxonomy scale, there is evidence that a deeper level of learning has taken place with the introduction of learning methods based on both of these prominent learning theories[82].

The sharing of knowledge among the students was greatly enhanced through the introduction of GBL methods based on Albert Bandura's social learning theory. Bandura (1977) believed that new behavioral patterns are acquired through direct experiences and the observations of behaviours of others. In a study of this nature, it is difficult to precisely quantify the effect that GBL has had in terms of notable outcomes, other than as part of the collective learning methods introduced (which included CBL). As a result of the introduction of the chosen learning methods showing a positive result in terms of outcomes over the semester[83], as well as from data obtained from the qualitative surveys in favour of GBL as a tuition method[84], the findings would concur with Bandura (1977) in that GBL has the ability to positively impact change with regards to student learning.

The introduction of CBL as a learning method was taken as a result of there being few practical resources available to the students. As a result of this, there became a need for the syllabi to incorporate a practical (more visual) component that the students could use their preferred learning and thinking styles to connect with and associate the written text with. The extensive use made of assignment maps allowed the students freedom to choose their preferred style of dealing with the material (Kolb, Boyatzis & Mainemelis, 2001), and their preferred method to think about the material in a manner that could possibly enhance their learning (Sternberg & Zhang, 2005; Piaget 1964). In this way, the students within this study were able to construct their own learning experience.

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[82] Figure 60 (chart) - Blooms taxonomy outcomes comparison (2014 to 2015)
[83] Figure 77 (table) - Learning outcomes summary
[84] Figure 72 (table) - Learning methods perception analysis (GBL)

The introduction of the chosen learning methods achieved positive results in terms of outcomes noted throughout the semester[85], and through affording the students to use their preferred thinking and learning styles in dealing with specific cases[86], the findings do concur with Kolb, Boyatzis & Mainemelis (2001) and Sternberg & Zhang (2005) in that CBL has the ability to positively impact change with regards to student learning.

8.2.5 <u>How the findings relate to practice</u>

(i) Critical thinking skills

The greatest impact noted during this CPUT DMS study was during the third phase, where the learning methods of GBL and CBL were introduced in an attempt to address the identified challenges that exist. These findings concurred with Burns (2014) who states that change can be highly discontinuous, whereby nothing really seems to be happening – until a tipping point is reached and more radical change is evoked.

South Africa's secondary schooling system still suffers from the legacy of apartheid, where critical thinking skills at the time were secondary to the implementation of policies. The move towards OBE, despite it being dropped in later years, was borne out of a desire to develop critical thinkers. With the aid of emerging technologies, scaffolding and selected learning methods, the development of the skills set within the workforce can become closer to the ideals of the South African government of creating a skills based economy (which was the original intention with the introduction of OBE at South African schools).

The improvements noted in terms of results, when the assessments were compiled to cover the first five segments of the Blooms taxonomy scale, indicate that the students are able to develop critical thinking skills. The Delphi method used to have the examinations assessed by peers within the industry (after the two-stage moderation process), confirmed that despite a rising examination standard in the final phase, the academic outcomes improved over previous methods used.

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[85] Figure 77 (table) - Learning outcomes summary
[86] Figure 62 (table) - Thinking and learning style analysis of devised CBT model

(ii) Computer literacy

While the research findings are positive with respect to the research question, the situation in developing countries regarding the lack of computer use for study purposes at a secondary school level places strain on the students when introduced to computers at institutions of higher learning. This became evident with the differences in outcomes noted at the S3 level students to that of the S4 level students.

This study thus also confirms the findings of Kanfer & Heggestad (1997) in that students with lesser computing skills may suffer from a form of computer anxiety, and perform more poorly when required to do certain computer-based tasks. As mentioned, this CPUT DMS study did not set out to research computer anxiety, however it has been noted as a factor that may require addressing to achieve further progress in successfully implementing CBT models of education.

Although the findings from this study agree with Novak's original belief that a lack of resources in developing countries could largely be obviated by the use of emerging technologies, it is important that the barriers to access to these technologies be removed for younger students if the true benefits of technology are to be derived when studying at a higher level. It is interesting to note how the findings from this study differ to those noted in the SMA study (Chatterjea & Nakazawa, 2008) where the older students were found to struggle more in comparison to the more junior students. In a developed country like Singapore, in general, school growing children are exposed to computers at a younger age, which aids to eliminate the computer anxiety aspect experienced in developing countries. The use of the single growth model as used in this CPUT DMS study to track the same students through successive semesters, indicated that the longer the junior students used computers - the better the noted outcomes. Significant differences were noted in the academic outcomes from these individuals after a 12 month period when compared to 6 months exposure to computer use.

(iii) Situated learning

With the introduction of classroom technology, there was evidence that by bringing in the various methods as aids to make the text comprehensible, certain key practical aspects associated with Marine Engineering could be 'simulated' within a classroom environment. The CBL assignments and discussion groups/communities of practice formed around the tasks stimulated debate among the students that became more akin to the types of discussions that would exist within the workplace onboard a ship.

The CBT model that was devised for this study improved throughout through constant evolvement. This was as a result of (a) student feedback obtained and (b) though student participation (collaboration), whereby the students were able to use their experiences and become providers of material to add towards the syllabi to compensate for the missing practical components.

8.2.6 The novelty of the research

This CPUT DMS study has successfully demonstrated that the introduction of a computer-based learning system that incorporates the learning methods described in order to address the environmental challenges that exist, has the ability to aid a maritime nation lacking practical resources. This study has also produced and tested the first known model that can allow for students to study remotely (at sea) without the need for an internet connection. This point is important for seafarers, who all enjoy Email access, but are limited by internet-data transmission via satellite. The inspiration for this type of system operation was borne out of witnessing how planned maintenance systems are used and updated on ships at sea.

In this way, it is possible that higher levels of qualifications could be studied towards without the need for taking leave or unpaid leave to attend classes for extended periods (which from 2018 / 2019 onwards, will be a three years continuous study program). The changing environment within MET in South Africa has resulted in a need for the development of systems such as this to cater for active seafarers, which will most likely involve a model based on blended learning principles and active engagement. In this regard, the model developed over the duration of this study will suitably meet the objectives. By developing a model that allows for students to contribute to the content (continuous build process) and to tailor the system towards their own particular learning and thinking style preferences, the process becomes more engaging for the students involved.

In South Africa there are currently only two appointed Class One Marine Engineering lecturers. With standard seafarer training (i.e. non degree programs) migrating towards distance learning as the norm in the near future, due to a lack of qualified lectures within the maritime industry, this system allows for distance learning programs to be run with a wide reach (i.e. different areas, seagoing students) with the very limited resources that are available.

8.2.7 Limitations

One of the challenges facing a researcher conducting single case study research, as was identified in the research method chapter, is the transferability of the study findings to other locations. The duration of the study, the limited number of MET institutions and approved lecturers at the disposal of the maritime industry in South Africa, prevented the study from taking place at more than one MET institution. The result of this form of research, however, was that a far deeper level of understanding of the environment, and of the research findings became possible than would be the case with more than one institution, owing to the intensity of the action research process within this singular environment. Additionally, the accountability towards maintaining accurate data collection procedures became paramount through an action research perspective, which may not have been the case through third-party data collection methods. Through in-depth research of this nature, it become possible to obtain a clear reflection as to how the research findings are able to answer the research questions posed, and their outcomes in relation to the literature.

To ensure validity of the data findings, multiple data collection and analysis methods were used in order to triangulate the research findings. From these multiple sources, relationships were identified where evident, and these relationships were used to form generalisations in terms of the possibility of the research findings having external validity (Tellis, 1997).

In the section that follows, the implications of the findings with regards to implementing computer-based learning methods for MET to be used for South African seafarers are detailed.

8.3 Conclusion

(1) Computer use in developing countries

The research findings showed that a divide exists between the abilities of the students, and the willingness to embrace computer technology between the junior and senior students. At the senior level, the data analysis conducted indicates that technology has the ability to compensate to some extent for a lack of practical resources in a developing country, thereby agreeing with Novak & Canas (2004). However, using technology at a lower level proved that the more junior students did not benefit from the introduction of classroom technology, as a result of the country having a developing secondary education system. This is primarily down to the fact that very few students entering the higher education stream were exposed to computer use while at secondary school. These findings are in line with Kanfer and Heggestad (1997) mentioned earlier who believe that students with lesser computing skills may suffer from computer-anxiety, resulting in them performing relatively poorly with regards to computer-based tasks.

Earlier introduction to computers at a foundation phase would benefit students at institutions of higher learning from where they could reap the benefits associated with the use of computer based MET models.

(2) Addressing the low experience levels and poor English language skills

The most significant difference analysed in terms of outcomes came in the third semester, when learning methods based on learning theories were introduced into the CBT model to address the challenges noted in the initial student information data collection process. Using GBL practices to review practical case studies (CBL) were shown enhance the understanding of the subject matter[87] for students who were unfamiliar with the equipment through lacking practical experience.

(3) Enhancement of critical thinking skills

Although somewhat limited in its use, when the assessments were compiled based on covering the key competences according to the Bloom's revised taxonomy scale, the

[87] Survey 4: Group based learning preference.

students were able to answer questions asked at a higher level, thereby demonstrating better levels of understanding than was previously the case. These improvements were noted during the course of the study, with understanding of higher order Bloom's taxonomy levels becoming progressively more evident as the study progressed.

(4) Development of a tool for distance learning in MET

While it was always the intention to develop a CBT system capable of requiring very low levels of data transmission, thereby being suitable for study at sea, this proved useful when student protest action (and university shutdowns) due to the #feesmustfall campaigns started in South Africa. The reality is that free education is not possible in the short term in South Africa, therefore, educational tools as demonstrated through the use of this open-source concept mapping platform can benefit those students wishing to continue studying despite access to the physical institution being denied in times of protest action.

It is important that the concerns regarding computer anxiety mentioned previously be addressed, before a distance-learning program can be successfully introduced. The introduction of a computer-familiarisation course and the establishment of adequate support elements for certain groups should therefore precede the introduction of any distance-learning program.

8.3.1 Recommendations for further research

This case study looked at improving educational practices within a single institution in a developing country, to ascertain whether or not the findings agree with those beliefs of Joseph Novak. This research is relevant in light of the position that maritime institutions find themselves in South Africa. The desire for government to see the industry develop, is not met by the resources at the disposal of the maritime institutions, nor by the funding models allocated to these institutions[88].

While the findings are primarily in agreement with the beliefs of Joseph Novak, further research of a similar nature could be conducted in another developing region, where students are exposed to computer use at an earlier level. Being limited with regards to

[88] See section 3.1 – Changes to MET programs in response to government funding models.

the number of MET institutions in South Africa, as well as challenges with regards to conducting a lengthy study of this nature at another institutions (each with their own education practices), the research field could benefit from further knowledge acquisition in a similar environment, in a country with other developmental challenges.

Similarly, although the research question and sub-questions were answered within a maritime domain within the contexts of this study, further research could pursue the acquisition of knowledge in this field in other industries that are external of the maritime domain.

It is recommended that this model be developed further over a longer period, built upon and researched in order to develop a system that can have a lasting impact on seafarer education. With further development, STCW maritime subjects can be offered through a blended or distance learning medium, thereby ensuring seafarer education in South Africa retains the current quality despite the higher educational institutions in South Africa turning towards degree based programs in the future.

Developing countries do face external factors that negatively impact the introduction of classroom technology that are aimed towards compensating for resources that are lacking. Future researchers in this field may want to consider addressing the challenges facing developing maritime nations with regards to bridging the gap between secondary school education and higher education, as this was found to be a limiting factor with regards to notable outcomes with this study. In South Africa, due regard needs to be paid to improving the quality of education and introducing the use of technology at secondary school level, to ensure a stronger feeder system into higher education can be achieved.

For the maritime education industry in South Africa to develop in line with international standards, the development of a quality feeder system for students wishing to pursue a maritime career is vital. Until a stage is reached where the governmental aims of operation Phakisa (maritime development) have been advanced, maritime education in South Africa will be challenged to meet the needs of industry under the current circumstances.

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GLOSSARY

Augmentation**:**	To add something to (something) in order to improve or complete it.
Bantu education:	Under the South African apartheid system, Bantu education was the official system of education for black South Africans.
Blended-learning:	Referring to a system whereby subject material delivery is conducted by more than one mode.
Case-based learning:	Case-based learning describes a learning method that makes use of referral to previous similar situations that have occurred (cases) and transfers any of that relevant knowledge to the particular situation that is being studied.
Collaborative learning:	Collaborative learning is based on the model that knowledge can be created within a population where members actively interact by sharing experiences and take on asymmetry roles.
Competency based:	Competency-based learning or Competency Based Education and Training is an approach to teaching and learning more often used in learning concrete skills than abstract learning.
Computer-based training (CBT):	Computer-based training (CBT) is any course of instruction whose primary means of delivery is a computer.

Constructionist:	Constructionism is a constructivist learning theory and theory of instruction. It states that the building of knowledge occurs best through building things that are tangible and shareable.
Cooperative learning:	Cooperative learning involves structuring classes around small groups that work together in such a way that each group member's success is dependent on the group's success.
Deductive:	With deductive reasoning, a conclusion is derived at by applying general rules that cover the entirety, and through narrowing the range under consideration until only one conclusion is left (top-down reasoning).
Dialectically:	Meaning of, relating to, or of the nature of logical argumentation.
E-learning:	For the purpose of this study, the term 'e-learning' is to be viewed with the aim of supplementing the classroom-based activities, as opposed to providing a distance-learning platform of education that the term often describes.
Hypermedia	A non-linear medium of information which includes graphics, audio, video, plain text and hyperlinks. This contrasts with the broader term multimedia, which may include non-interactive linear presentations as well as hypermedia.
Impact**:**	Measure of the tangible and intangible effects (consequences) of one thing's or entity's action or influence upon another.
Inductive:	Inductive is a way to describe something that leads to something else, and when applied to reasoning, it refers to

the collection of information to draw conclusions from what is observed (bottom-up logic).

Inquiry-based learning: Inquiry-based learning is an inductive aid to cognitive development through taking knowledge learned from one source and transferring that knowledge to a new application or scenario.

Interdependence: Interdependence refers to the degree to which members of a group are mutually dependent on the others. This concept differs from a dependent relationship, where some members are dependent and some are not.

Knowledge management system (KBS)**:** Knowledge management systems refer to any kind of IT system that stores and retrieves knowledge, improves collaboration, locates knowledge sources, mines repositories for hidden knowledge, captures and uses knowledge, or in some other way enhances the KM process.

Learning management system (LMS)**:** A learning management system (LMS) is a software application for the administration, documentation, tracking, reporting and delivery of electronic educational technology (also called e-learning) education courses or training programs.

Learning outcomes: Learning outcomes are statements that describe significant and essential learning that learners have achieved, and can reliably demonstrate at the end of a course or program. The Blooms revised taxonomy model is often used to ascertain learning outcomes.

Longitudinal:	An epidemiologic study that follows a population forward over time, evaluating the effects of one or more variables on a process. Many years.
Multimedia:	Multimedia is content that uses a combination of different content forms such as text, audio, images, animation, video and interactive content. Multimedia contrasts with media that only uses only rudimentary computer displays such as text-only or traditional forms or printed or hand-produced material.
Outcomes based education:	Outcome-Based Education means clearly focusing and organizing everything in an educational system around what is essential for all students to be able to do successfully at the end of their learning experiences.
Problem-based learning:	Problem-based learning is a student-centered pedagogy in which students learn about a subject through the experience of solving an open-ended problem.
Promotive interaction:	Promotive interaction refers to a system whereby the students promote each other's success by sharing knowledge and resources.
Reflexive:	Refers to the circular relationship that exists between cause and effect.

APENDICES

MARINE ENGINEERING: STUDENT INFORMATION SURVEY

SURVEY 1

As part of research towards a PhD in Maritime Education and Technology, you are kindly requested to participate in completing the following voluntary questionnaire. The information obtained is to be used towards developing and implementing a Marine Engineering learning management system (language-assisted - for those students whose home language is not English).

The learning management system is to be developed in line with the information derived from these questionnaires, so as to provide an educational offering in that is best suited to the South African Marine Engineering student in Southern Africa.

Participation in this survey is purely voluntary, and participation will in no way impact upon a students' final assessment, or participation in the Marine Engineering programme. All information for the purpose of this research is to be kept in the strictest confidence, and anonymity is guaranteed. No personal information is to be published, however should this be deemed necessary, this will only be done with prior written consent from the individuals concerned. All data obtained is to be used for academic research only, and securely kept until disposal thereof upon conclusion of this study.

This study is being done at the World Maritime University in Malmö, Sweden, and is funded by SAMSA, for the purpose of developing the South African maritime industry.

I consent to my personal data, as outlined in the accompanying information sheet, being used for this study and other research. I understand that all personal data relating to volunteers is held and processed in the strictest confidence.

Signed: ______________________________

Thank you for your time.

Derek Lambert
PHD Candidate
World Maritime University
Malmö, Sweden

SECTION A – Please list your details in the spaces provided below.

A1. Date: ______________________________________

A2. Name: ___________________________ **A3.** Student Number: ____________

A4. Nationality: __________________________________

A5. Languages: (1^{st}) _________________________ (2^{nd}) ___________________________

(3^{rd}) __________________________ (4^{th}) ___________________________

A6. Years Spent at Sea: (0) _____ (0-2) _____ (2-5) _____ (5-8) _____ (>8) _____

A7. Do you have access to the internet at home, or your place of residence in Cape Town:

(Y) _____ (N) _____

A8. Do you own a laptop computer: (Y) _____ (N) _____

IF THE ANSWER TO A6 (above) IS ZERO, PLEASE SKIP TO SECTION D

A9. Current position: ______________________ **A10.** Company: ________________________

A11. Last Vessel: _________________________ **A12.** Vessel Age: _______________________

A13. Certificate of Competency Held: ____________________________________

A14. Did you have internet access on your last vessel: (Y) _____ (N) _____

A15. Will you be going for SAMSA orals directly after completing this course: (Y) _____ (N) _____

SECTION B – Please list your experience with the following types of vessel.

PLEASE LIST (IN YEARS) THE AMOUNT OF YEARS SPENT ONBOARD THE FOLLOWING VESSELS:

B1. Bulk Cargo Carriers: (0) _____ (0-2) _____ (2-5) _____ (5-8) _____ (>8) _____

B2. Container Vessels: (0) _____ (0-2) _____ (2-5) _____ (5-8) _____ (>8) _____

B3. Offshore Supply: (0) _____ (0-2) _____ (2-5) _____ (5-8) _____ (>8) _____

B4. Mining/Oil Platforms: (0) _____ (0-2) _____ (2-5) _____ (5-8) _____ (>8) _____

B5. Research Vessels: (0) _____ (0-2) _____ (2-5) _____ (5-8) _____ (>8) _____

B6. Cable Laying Vessels: (0) _____ (0-2) _____ (2-5) _____ (5-8) _____ (>8) _____

B7. Naval Vessels: (0) _____ (0-2) _____ (2-5) _____ (5-8) _____ (>8) _____

B8. Fishing Vessels: (0) _____ (0-2) _____ (2-5) _____ (5-8) _____ (>8) _____

B9. Tankers: (0) _____ (0-2) _____ (2-5) _____ (5-8) _____ (>8) _____

B10. Other (Please Specify): ____

____

SECTION C – Please list your experience with the following types of equipment.

PLEASE LIST (IN YEARS) THE AMOUNT OF YEARS SPENT WORKING WITH THE FOLLOWING TYPES OF MACHINERY.

C1. Four Stroke Engines: (0) _____ (0-2) _____ (2-5) _____ (5-8) _____ (>8) _____

C2. Two Stroke Engines: (0) _____ (0-2) _____ (2-5) _____ (5-8) _____ (>8) _____

C3. Gas Turbines: (0) _____ (0-2) _____ (2-5) _____ (5-8) _____ (>8) _____

C4. Marine Boilers: (0) _____ (0-2) _____ (2-5) _____ (5-8) _____ (>8) _____

C5. Thermal Fluid Systems: (0) _____ (0-2) _____ (2-5) _____ (5-8) _____ (>8) _____

C6. Cable Laying Vessels: (0) _____ (0-2) _____ (2-5) _____ (5-8) _____ (>8) _____

C7. Steam Turbines: (0) _____ (0-2) _____ (2-5) _____ (5-8) _____ (>8) _____

C8. CPP Propulsion: (0) _____ (0-2) _____ (2-5) _____ (5-8) _____ (>8) _____

C9. Voith Schneider: (0) _____ (0-2) _____ (2-5) _____ (5-8) _____ (>8) _____

C10. DC Electrical Propulsion: (0) _____ (0-2) _____ (2-5) _____ (5-8) _____ (>8) _____

C11. AC Electrical Propulsion: (0) _____ (0-2) _____ (2-5) _____ (5-8) _____ (>8) _____

C12. High Voltage Systems: (0) _____ (0-2) _____ (2-5) _____ (5-8) _____ (>8) _____

C13. Azimuth Pods: (0) _____ (0-2) _____ (2-5) _____ (5-8) _____ (>8) _____

C14. Dynamic Positioning: (0) _____ (0-2) _____ (2-5) _____ (5-8) _____ (>8) _____

C15. Cathodic Protection: (0) _____ (0-2) _____ (2-5) _____ (5-8) _____ (>8) _____

C16. Rotary Vane Steering: (0) _____ (0-2) _____ (2-5) _____ (5-8) _____ (>8) _____

C17. Hydraulic Ram Steering: (0) _____ (0-2) _____ (2-5) _____ (5-8) _____ (>8) _____

SECTION D – Please answer the following questions regarding your studies.

D1. Are you a Diploma or Non-Diploma Candidate:

(DIPLOMA) ___________ (NON-DIPLOMA) _____________

D2. Please list the number of subjects you are enrolled for: ____________________

SECTION E – Please complete the following assignment as described below.

Please read the following page, and circle any words you do not understand, or are unfamiliar with.

Article 1: Pounders Marine Diesel Engines and Gas Turbines (8th Ed.)

New designs and upgraded versions of established models have maintained the dominance of medium speed four-stroke diesel engines in the propulsion of smaller ships as well as larger specialist tonnage such as cruise vessels, car/passenger ferries and ro-ro freight carriers. The larger bore designs can also target the mainstream cargo ship propulsion market formed by bulk carriers, containerships and tankers, competing against low speed two-stroke machinery. The growth of the fast ferry sector has benefited those medium speed engine builders (notably Caterpillar and Ruston) who can offer designs with sufficiently high power/weight and volume ratios, an ability to function reliably at full load for sustained periods, and attractive through-life operating costs. Medium speed engines further enjoy supremacy in the deep sea genset drive sector, challenged only in lower power installations by high speed four-stroke engines.

Significant strides have been made in improving the reliability and durability of medium speed engines in the past decade, both at the design stage and through the in-service support of advanced monitoring and diagnostic systems. Former weak points in earlier generations of medium speed engines have been eradicated in new models which have benefited from finite element method calculations in designing heavily loaded components. Designers now argue the merits of new generations of longer stroke medium speed engines with higher specific outputs allowing a smaller number of cylinders to satisfy a given power demand and foster compactness, reliability, reduced maintenance and easier servicing. Progress in fuel and lubricating oil economy is also cited, along with enhanced pier-to-pier heavy fuel burning capability and better performance flexibility throughout the load range.

Completely bore-cooled cylinder units and combustion spaces formed by liner, head and piston combine good strength and stiffness with good temperature control which are important factors in burning low quality fuel oils. Low noise and vibration levels achieved by modern medium speed engines can be reduced further by resilient mounting systems, a technology which has advanced considerably in recent years.

IMO limits on nitrogen oxides emissions in the exhaust gas can generally be met comfortably by medium speed engines using primary measures to influence the combustion process (in some cases, it is claimed, without compromising specific fuel consumption). Wärtsilä's low NOx combustion technology, for example, embraces high fuel injection pressures (up to 2000 bar) to reduce the duration of injection; a high compression ratio (16:1); a maximum cylinder pressure of up to 210 bar; and a stroke/bore ratio greater than 1.2:1. Concern over smoke emissions, particularly by cruise ship operators in sensitive environmental areas, has called for special measures from engine designers targeting that market, notably electronically-controlled common rail fuel injection and fuel-water emulsification.

THANK YOU – YOUR PARTICIPATION IS APPRECIATED D. LAMBERT

MARINE ENGINEERING: STUDENT INFORMATION SURVEY

CBT QUALITATIVE SURVEY : SURVEY 2

As part of research towards a PhD in Maritime Education and Technology, you are kindly requested to participate in completing the following voluntary questionnaire. The information obtained is to be used towards developing and implementing a Marine Engineering learning management system (language-assisted - for those students whose home language is not English).

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I consent to any data, as outlined in the accompanying information sheet, being used for this study and other research. I understand that all personal data relating to volunteers is held and processed in the strictest confidence.

Signed: ______________________________

Thank you for your time.

Derek Lambert
PHD Candidate
World Maritime University
Malmö, Sweden

COMPARING THE CONCEPT MAPPING E-LEARNING LMS TO THE PAPER BASED SYLLABUS

(1) COURSE LAYOUT & CONFIGURATION

(a) Please list the enhancements (if any) that the digital LMS has over the paper-based method of tuition used previously.

(b) Please list the negative aspects (if any) that the digital LMS system has when compared to the previously used paper-based syllabus.

(c) Do you feel the layout of the course (structure/configuration) was better or worse than the paper-based syllabus used previously (please circle below).

BETTER **WORSE**

(d) Do you feel that enough use was made of visual media (i.e. images, animations, video clips), bearing in mind the need to keep data storage sizes manageable.

YES **NO**

(e) Did you find information retrieval easier within the Concept Mapping environment?

YES **NO**

(2) COURSE ENGAGEMENT

Which of the two systems do you feel has the ability to better engage students with the course material.

COMPUTER-BASED **PAPER-BASED**

(3) TIME SPENT WITH MATERIAL

In your opinion, which of the two systems required a greater amount of time to be put in to your studies?

COMPUTER-BASED **PAPER-BASED**

(4) COURSE PLANNING

Did the revised course layout (chapters) and rigid structure of the 'planner' help you to manage your study time better?

YES **NO**

(5) CONCEPT MAP ASSIGNMENTS

(a) Please indicate which type of "3rd assessment" you feel has the most merit in terms of examination preparation.

PROJECT **WEEKLY MAPS**

(b) Which of the two systems required you to make greater use of textbooks in order to retrieve information?

COMPUTER-BASED **PAPER-BASED**

(c) Do you feel that the assignments will be of value when it comes to subject revision for examination purposes?

YES **NO** **NOT SURE**

(d) For the S1 and S2 students, do you think the “procedure” and “sequence” maps can help them understand engineering systems and concepts better?

YES **NO** **NOT SURE**

(6) FUTURE LMS DEVELOPMENT

(a) Please list any items you feel would add value to the course in the future if they could be added to the LMS.

(b) Please list any items you feel should be omitted from the course in the future.

THANK YOU – YOUR PARTICIPATION IS APPRECIATED D. LAMBERT

MARINE ENGINEERING: LEARNING PREFERENCE SURVEY

SURVEY 3

As part of research towards a PhD in Maritime Education and Technology, you are kindly requested to participate in completing the following voluntary questionnaire. The information obtained is to be used towards developing and implementing a Marine Engineering learning management system (language-assisted - for those students whose home language is not English).

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I consent to any data, as outlined in the accompanying information sheet, being used for this study and other research. I understand that all personal data relating to volunteers is held and processed in the strictest confidence.

Signed: ________________________________

Thank you for your time.

Derek Lambert
PHD Candidate
World Maritime University
Malmö, Sweden

LEARNING STYLES

(a)

Please state your preferred method of study
(Please circle your preference below):

BOOKS & PAPER **COMPUTER DOCUMENTS**

(b) Please indicate which of the following statements you believe is the most truthful with regards to yourself (please circle the letter of your preference):

A - "The amount of work was too much, my main aim was to learn just what is required to pass the assessments"

or

B - "I used all of the information provided to try understand the subjects the best that I could"

(c) Given the time frame we have with which to run the course…

Do you think that the development of a computer program (pictures, course layout, animations etc.) can help those students who have never been to sea before?

Please circle your preference below

Not really **Limited help** **A lot of help** **Completely**

(d) Please list any items you feel should be added to the course in the future.

Please list any items you feel should be removed from the course in the future.

THANK YOU – YOUR PARTICIPATION IS APPRECIATED **D. LAMBERT**

MARINE ENGINEERING: STUDENT INFORMATION SURVEY

SURVEY 4

As part of research towards a PhD in Maritime Education and Technology, you are kindly requested to participate in completing the following voluntary questionnaire. The information obtained is to be used towards developing and implementing a Marine Engineering learning management system (language-assisted - for those students whose home language is not English).

The learning management system is to be developed in line with the information derived from these questionnaires, so as to provide an educational offering in that is best suited to the South African Marine Engineering student in Southern Africa.

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I consent to any data, as outlined in the accompanying information sheet, being used for this study and other research. I understand that all personal data relating to volunteers is held and processed in the strictest confidence.

Signed: ______________________________

Thank you for your time.

Derek Lambert
PHD Candidate
World Maritime University
Malmö, Sweden

LEARNING STYLES

(a) To what extent do you feel that interaction with other students in the class contributed to you understanding certain sections of the work better?

Please circle the appropriate answer.

NOT MUCH **A FAIR AMOUNT** **A LOT** **COMPLETELY**

(b) In light of there being no practical component to this course, please list the below mentioned items in order of importance - **(1 being the most important and 4 the least important).**

_________ Case studies of past accidents and shipping casualties.

_________ The addition of photographs from actual South African ships to the course.

_________ The inclusion of more material from manufacturer's technical manuals.

_________ The inclusion of manufacturer's product brochures.

(c) Please indicate which of the following statements you believe is the most truthful with regards to yourself (please circle the letter of your preference):

A - **"The amount of work was too much, my main aim was to learn just what is required to pass the assessments"**

or

B - **"I used all of the information provided to try understand the subjects the best that I could"**

(d) Given the time frame we have with which to run the course…

Do you think that the development of a computer program (pictures, course layout, animations etc.) can help those students who have never been to sea before?

Please circle your preference below

Not really **Limited help** **A lot of help** **Completely**

COURSE DEVELOPMENT

(e) Please list any items you feel should be added to the course in the future.

Please list any items you feel should be removed from the course in the future.

THANK YOU – YOUR PARTICIPATION IS APPRECIATED **D. LAMBERT**

APPENDIX 1: STATISTICAL T-TEST FORMULATION

	Column A	Column B
	XX	XX
	XX	XX
	XX	XX
	XX	XX
	XX	XX
	XX	XX
	XX	XX
Mean	XX	XX
SDEV	XX	XX
COUNT	XX	XX

Stat	Value	Formula
Sum of the Squared Deviations [SOSD][1]	XX	=DEVSQ(Column**A**)+DEVSQ(Column**B**)
Pooled Sample Variance [PSV][2]	XX	=**SOSD**/(COUNT**A**-1+COUNT**B**-1)
Standard Error of Difference in Means [SEODM][3]	XX	=SQRT(**PSV***(1/COUNT**A**+1/COUNT**B**))
Calculated T-stat	XX	=(Mean**A**-Mean**B**)/**SEODM**
Critical T-value @0,95	XX	=TINV(0,05*2, **DOF**)
Degrees of Freedom [DOF][4]	XX	=(1/COUNT**A**+**U**/COUNT**B**)^2/(1/(COUNT**B**^2*(COUNT**B**-1))+**U**^2/(COUNT**C**^2*(COUNT**C**-1)))
U (Used in DOF Calculation)	XX	=Mean**B**^2/Mean**A**^2

Appendix 2: Previous studies involving concept mapping (Cañas et al., 2003)

DATE	LOCATION	LEVEL	SAMPLE SIZE	DURATION	ASSESSMENTS	PURPOSE
1998	Canada	Primary School	48	Stated as being short (unknown)	3 Assessments (3 forms)	To test the effects on academic knowledge base retention (Biology)
2002	Taiwan	Primary School	126	4 weeks	2 Assessments (Pre & Post tests 400-820 Chinese characters)	To test the benefits of learning from 3 different kinds of concept maps (General Science)
1985	Venezuela	Secondary School	76	Unknown	8 Assessments	To test the effects on problem solving (Physics)
1985	USA	Secondary School	Unknown	10 classes	2 Assessments (Pre & Post tests – 32 items)	To test the effects of concept mapping vs. outlining (Biology)
1989	USA	Secondary School	151	3 weeks	1 Assessment	To test the effects of concept mapping vs. concept defining (Biology & Chemistry)
1990	Canada	Secondary School	Stated as being small (unknown)	Stated as being short (unknown)	2 Assessments	To test the effects on academic achievement (Biology)
1990	USA	Secondary School	87	6 weeks	1 Assessment (30 items)	To test the effects on problem solving (Physics)
2002	USA	Under Graduate Students	Unclear (+/- 149)	Conducted via internet – not mentioned	1 Assessment	To test the effects of text transfer vs. completed concept maps vs. blank scaffold maps (General)
1990	Nigeria	Secondary School	51	6 weeks	1 Assessment (50 items)	To test the effects on academic achievement & anxiety reduction (Biology)
1995	Nigeria	Secondary School	808	Unknown	3 Assessments	To test the effects with different forms of instruction (Ecology)

DATE	LOCATION	LEVEL	SAMPLE SIZE	DURATION	ASSESSMENTS	PURPOSE
1989	USA	Under Graduate Students	186	3 sessions (75 minutes each)	2 Assessments	To test the effects of supplemental materials across three styles of instruction (Psychology)
1996	USA	Under Graduate Students	43	2 days	1 Assessment	To test the free recall of memory from either text vs. concept maps (Psychology)
1997	USA	Under Graduate Students	73	2 days	1 Assessment	To test the effects of learner generated enhancements of learning material [including concept maps] (Psychology)
1998	USA	Under Graduate Students	118	8 weeks	1 Assessment (100 items)	To test the effects on academic achievement & anxiety reduction (Physics)
1999	USA	Under Graduate Students	90	2 days	1 Assessment	To test the effects on outcome from interacting differently with concept maps (Psychology)
2001	USA	Under Graduate Students	20	One session of course (unknown)	Structured interviews	To test the effects on academic knowledge base retention (Chemistry)
CONCEPT MAPPING STUDIES IN MARITIME EDUCATION						
DATE	**LOCATION**	**LEVEL**	**SAMPLE SIZE**	**DURATION**	**ASSESSMENTS**	**PURPOSE**
2008	Singapore	Maritime Students (Senior level)	37	Not stated (Steam course)	6 Assignments	Development of Steam conversion course for Senior Marine Engineering officers
2014 2015	South Africa	Maritime Students (Senior level)	118	18 months (4 subjects)	72 Assessments	To test the effectiveness of technology used to counter the lack of available resources within the South African maritime industry