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Student Perspectives of Open Book versus Closed Book Examinations—a Case Study in Satellite Communication*

ARTHUR JAMES SWART
Central University of Technology, Private Bag X20539, Bloemfontein, South Africa, 9300. E-mail: drjamesswart@gmail.com

TRUDY SUTHERLAND
Vaal University of Technology, Private Bag X021, Vanderbijlpark, 1900, South Africa.

The purpose of this article is to present student perspectives of open book examinations, contrasting them to those for closed book examinations. Reasons and advantages of using open book examinations are offered and may be aligned with important accreditation criteria stipulated by official accreditation bodies, such as the Engineering Council of South Africa. The perspectives of senior electrical engineering students, enrolled in a telecommunications module, regarding open book examinations from two higher educational institutes in South Africa were obtained using a questionnaire survey. More than 80% of students from a residential contact university and less than 60% of students from an open distance learning institute passed their open book examination. The questionnaire survey highlighted that more than 50% of the polled students would prefer open book examinations.

Keywords: open book; closed book; examinations; accreditation; perspectives; open distance learning

1. Introduction

The Vaal University of Technology (VUT) [1] is a higher educational institute providing on-campus contact education (both theoretical and practical) to approximately 22 500 residential students. The University of South Africa (UNISA) is the largest open distance learning institute on the African continent providing distance education to some 350 000 non-residential students [2]. Both Universities offer a National Diploma in Electrical Engineering and are therefore mandated by the Engineering Council of South Africa (ECSA) to provide quality engineering education programmes which adhere to the high standards set forth by the Washington, Sydney and Dublin Accords [3]. These Accords list a number of graduate attribute profiles which engineering students must meet to be considered as professional engineers, technologist and technicians.

The fundamental purpose of engineering education is to build a knowledge base and attributes to enable graduates to continue learning and to proceed to formative development that will advance the competencies required for independent practice [4]. Current emphasis in South Africa today is on the acquisition of knowledge as a productive force. However, it is not merely any knowledge, but the application of theoretical, codified knowledge that allows individuals to add direct value to the socio-economic development of the country [5, 6]. Subsequently, engineering academics need to assess the formative development of engineering students by using diverse assessment techniques suited to the graduate attribute profiles.

The first three of these attribute profiles focuses on engineering knowledge, problem analysis and design. Assessing these attributes in different engineering education programmes cannot simply involve the use of recall questions, or lower order questions [7]. A typical lower order question in a telecommunications subject would be "List three types of satellite orbits currently in use today". The answer to this question may be copied directly from a prescribed textbook. However, this type of question may be rephrased as a higher order question. For example, it may be stated that a satellite is used to broadcast news channels 24 hours a day to South Africa. The question may then be phrased "Conclude what type of orbit is used with this satellite?" The student will have to use critical thinking with this question, using the application of the satellite in this question to arrive at the right conclusion. Questions therefore need to be changed from the commonly used list, describe and define questions (lower order) to evaluate, conclude and deduce questions (higher order). Higher order questions must be used to determine if formative development has occurred where students demonstrate critical thinking along with logical reasoning. One assessment technique which may be tailored to include both lower and higher order questions to assess student learning involves the use of open book examinations (o-b-e).

However, academics are divided on the use of o-b-e. For example, Smith, Feller and Cain all argued

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in favour of o-b-e as they expected them to encourage higher order thinking and deeper learning approaches [8–10]. On the other hand, Moore and Jensen (2007) argue against o-b-e as they diminish long-term learning and promote academic behaviors that typify lower levels of academic achievement [11]. Subsequently, this article attempts to contrast o-b-e to closed book examinations (c-b-e), highlighting advantages, disadvantages and applications within an engineering education context. Secondly, a brief description of the case study used in this research, namely Satellite Communications IV, is given, from where student perspectives are derived. Thirdly, the research methodology is substantiated and the results of the questionnaire are presented in a series of graphs and tables. Succinct conclusions then follow.

2. Open book versus closed book examinations

University student profiles have changed socially, culturally, and economically with the 'massification' of higher education [12], with corresponding remarkable changes in the area of educational technology also being observed. A growing body of research has shown that taking an examination can do more than simply assess learning; it can also enhance learning and improve long-term retention, a phenomenon known as the testing effect [13–16]. In classroom settings, tests and quizzes are typically administered for assessment purposes. In laboratory settings, tests and quizzes not only measure knowledge, but also change and enhance memory for information [17]. The fact that students engage in cognitive processes that promote learning when taking a test is often overlooked in education.

The first level, known as cognitive functioning, includes general thinking and reasoning abilities. The second level, known as meta-cognitive functioning, deals with thinking about one's thoughts. The third level, known as epistemic cognition, deals with understanding how to approach problems [18]. All three levels can be applied to o-b-e and c-b-e, despite their differences when it comes to their meaning, application and implementation. The main dissimilarity between these two examination techniques is that c-b-e places higher emphasis on accurate and widespread memory recall and reproduction of information. C-b-e generally represent the norm in higher education, where students take the examination without the aid of their notes or textbooks, and consulting supplementary material is typically considered cheating [9, 19]. If not carefully designed, this assessment of student learning is likely to be dominated by the recall ability. However, intelligently designed c-b-e can be used to test critical thinking and subsequently higher order skills.

The ability to recall information is an important cognitive goal; however, it is the lowest order skill according to Bloom's hierarchy of educational objectives in the cognitive domain [20] and is therefore an essential forerunner to the higher order skills. Results from several studies converge on the conclusion that recall examinations promote better long-term retention than recognition examinations, regardless of whether the final criteria requires recall or recognition [21–24]. In addition, the concept of desirable difficulty suggests that more challenging test conditions may slow initial learning, but ultimately result in enhanced final performance [25]. One theory of this testing effect suggests that examinations requiring more challenging retrieval questions produce greater benefits for long-term retention [13, 15, 17, 26]. However, in engineering education, long-term application may be more important than long-term retention. Graduates need to be able to apply knowledge to new situations on a consistent basis, especially when the knowledge changes and adapts constantly to new technological developments. For example, it is reported in Information Technology that 50% of its current knowledge changes every year [27], and is referred to as the half-life of knowledge. Other research indicates that the amount of knowledge in the world has doubled over the past 10 years and is doubling every 18 months [28]. Subsequently, of what value is long-term retention if knowledge turnover occurs so frequently? However, if graduates have been trained to access information appropriately from a textbook and apply it correctly in a distinctive setting, then the teaching and learning process has been enhanced! Nevertheless, long-term retention is important in o-b-e as students need to remember the location of important sections within their textbook. More important is the ability to efficiently use the Table of Contents and the Index in a textbook to locate important theoretical sections. This will aid students later in life to find information in other textbooks, thereby contributing to establishing an attitude of life-long learning. It is noteworthy that Agarwal et al. [29] notes that no differences in memory benefits between o-b-e and c-b-e have yet been determined.

Students often prepare for c-b-e by looking at previous examination papers and spotting probable questions. Thereafter, students construct or find model answers to these questions and memorise them. If students can spot and prepare likely questions for an o-b-e, then the examination is not even testing memory recall, only the copying of information from one examination to another. Hence, o-b-e cannot include repetitive questions being used from one question paper to another. This requires academics to put forth more effort in developing different questions based on the published material, thereby forcing them to engage with the material on a consistent basis. This in turn may lead to satisfying important accreditation criteria stipulated by accreditation bodies, such as ECSA. ECSA [30] is responsible for the accreditation of engineering programmes and ensuring quality education within the various disciplines of engineering. Every four to five years ECSA visits institutions of higher learning in South Africa who offer engineering programmes to scrutinize, amongst other things, examination papers for repetitive questions (which is NOT allowed) and for the consistent use of predefined exit level outcomes (ELO). Engineering students need to meet these ELO if they are to become qualified artisans, professional technicians or technologists within the industrial sector. These ELO include problem-solving skills, application of scientific and engineering knowledge, engineering design, communication, engineering management and the application of complementary knowledge. All these ELO can be successfully assessed using o-b-e which feature appropriate higher order level questions.

O-b-e permit students to access selected sources (such as their own notes, the lecturer's hand-outs, or textbooks) while answering the questions. The reference material used during the examination period is usually well-known to the students, and often includes the prescribed textbook of the course. This means that students are forced to purchase and read their own copies (prescribed textbook) in preparation for the examination, instead of borrowing a copy from a fellow student for study purposes. They are also encouraged to write notes within their own copies, thereby expressing the information in their own words and handwriting. This in turn re-enforces the learning process as students engage with the published literature on a regular and constant basis.

O-b-e is not as easy as students may think. At times it can be more difficult than c-b-e as students are not used to o-b-e which require a different study approach. It may therefore be necessary to help students change their study habits by giving quizzes and mock examinations during the course in preparation for the final examination. On the other hand, educators who support the use of o-b-e acknowledge that students may find these examinations to be less challenging than c-b-e [19, 31]. In addition, students report that they experience less stress and anxiety when preparing for o-b-e (as compared to c-b-e) [32–34], which are also extremely beneficial for those students who find memorising paragraphs difficult [29, 35]. For these reasons, some educators argue that o-b-e promote and assess learning more effectively than traditional c-b-e [31, 36, 37].

It must though be noted that o-b-e are unsuitable in a course that expects students to memorise the information given to them, and reproduce it during the examination. However, an o-b-e is more appropriate if a course expects students to be able to process new information. O-b-e is not suitable if a course aims to test understanding through exposition, but is very suitable if it aims to test understanding through application to new situations [38]. O-b-e can indirectly test student mastery of content by testing how well the student is able to apply specific theoretical knowledge to new situations. Challenging the retrieval and application processes is known to promote long-term retention of information [13, 17, 26, 39].

In order to ascertain students' perceptions of o-b-e, a questionnaire was designed and administered at the start of a subject/module entitled Satellite Communication IV. The objective was to find out to what extent students preferred this mode of assessment and to ascertain their perceptions of this type of examination.

3. A brief overview of the case study, Satellite Communications IV

Satellite Communication IV is a BTech module offered over a semester period (approximately 14 weeks) at VUT and over a year period (approximately 8 months) at UNISA (see Table 1 for the course structure and assessment—note that the practical work is part of the theory module at VUT but registered as a separate module at UNISA).

Table 1. Course structure and assessment

Vaal University of Technology	**Institution**	University of South Africa
Residential contact	**University type**	Open distance learning
2 × written tests in a classroom and 2 online tests (30% weight)	**Pre-exam assessments**	3 × written assignments (10% weight)
Part of the module where 10 practical experiments are done (20% weight)	**Practical work**	Module on its own with a practical day being scheduled (100% weight)
1 x open book exam (50% weight)	**Examination at the end**	1 × open book exam (90% weight)
Theory and practical = 12	**Credits**	Theory = 10 and practical = 2

Note in Table 1, that the practical work is done separately from the theory work at UNISA. However, both modules need to be taken to complete the course. The reason for splitting the practical and theory is to make sure that distance learning students engage with the practical experiments, so as to satisfy accreditation requirements from ECSA. However, the credit bearing value of the module at both universities is the same, with VUT giving 12 credits to their module and UNISA giving 10 credits to their theory part and 2 credits to their practical part. Note too that all the pre-exam assessments are open book, resulting in a year mark for the student which is combined with the final o-b-e to give a final grade mark. All pre-exam assessments are formative in nature, while the final examination at the end of the course is summative, being written in a venue with an invigilator present.

Students have to obtain a minimum of 120 credits at this level to be awarded the BTech: Engineering: Electrical qualification. The majority of modules in this BTech programme have a credit value of 12, with the exception of a capstone module (termed Industrial Projects 4) which has 36 credits attached to it. VUT operates on a semester basis of almost four months while UNISA offers year modules for their BTech programme. During this time, students at VUT complete four venue based assessments (open book) in preparation for their examination, while students at UNISA submit three written assignments (usually via post) based on predefined questions set by the lecturer the year before. Bear in mind that students have four hours of contact per week with their lecturer at VUT, while students only have email access to their lecturers at UNISA. Many UNISA students are employed full-time, and therefore have to balance their academic studies with their work commitments. Subsequently, UNISA students need to be given more time to understand the course content, which is the same at both universities and presented by the same lecturer. However, they cannot write the exact same o-b-e as their examination dates are fixed differently which could cause students from one university to share the question paper with students from the other university before it is written!

The Satellite Communication IV syllabus covers four main sections, being orbital parameters, link design, satellite architecture and earth stations. Orbital parameters feature a number of mathematical calculations along with extensive application of acquired knowledge, and accounts for approximately 30% of the final written examination. The link design section considers all the gains and losses associated with a satellite earth station communications link, being one of the major singular calculations comprising approximately 25% of the final written examination. Satellite architecture considers access techniques, the platform, the payload and space environments. Earth stations present information relating to telemetry, tracking, control, amplifiers, reliability and availability. The last two sections tally approximately 45% of the final written examination, where the interpretation of the information is assessed rather than its recall. For example, students are asked to calculate the carrier to noise ratio for a given downlink, evaluating the final answer against predefined standards and then suggesting possible improvements to the system. These typical verbs used in the o-b-e places particular emphasis on the use of the upper levels of Blooms Taxonomy which contribute to deep learning and critical-thinking [7].

Electrical engineering students must be in possession of a National Diploma (minimum of 3 years to complete) before they can register for the BTech programme which can be completed within a year if they are enrolled full-time. C-b-e was originally used when this module was first offered. However, it was converted to o-b-e at VUT in 2007 and at UNISA in 2011, for the following reasons:

- Student reasoning ability needed to be assessed in place of student memory recall;
- Too much emphasis was being placed on what students could recall, instead of what they can do;
- Student ability to learn and retain large volumes of information was deteriorating;
- Note taking and synthesis of information by students needed to be encouraged;
- Students were not purchasing the prescribed textbook;
- Surface learning was taking priority over deep learning;
- Student profile had changed; and
- The throughput/pass rate was consistently fluctuating.

4. Research methodology used in this article

A time-lag study was used in this research, along with descriptive statistics, to examine and evaluate the results of c-b-e and o-b-e (see Table 2). Descriptive statistics occur where a specific situation is studied to see if it gives rise to any general theories, while in a time-lag study one could, say over a four year period, determine the attitudes of each year's group towards a particular event or notion [40]. The specific situation was limited to the type of final examination in a telecommunications module which may give rise to a particular theoretical perception, while the attitude of different students towards o-b-e within the same module over a

Table 2. Time periods for using closed book and open book examinations

University	VUT	UNISA
Time period for c-b-e without questionnaires	2003–2005 (3 groups with an average of 16 students each per year)	2006–2010 (5 groups with an average of 21 students each per year)
Time period for o-b-e without questionnaires	2007–2009 (2 groups with an average of 20 students each per year)	NA
Time period for o-b-e with questionnaires	2011 and 2012 (2 groups with an average of 22 students each per year)	2011 and 2012 (2 groups with an average of 36 students each per year)

specific time period was obtained. The target population was restricted to all students enrolled for the Satellite Communications module during the time periods shown in Table 2, therefore requiring no sampling technique. Nothing was done differently between the c-b-e and o-b-e, except that the textbook was either banned or allowed in the venue for the final examination!

A questionnaire was used as the data collection tool to ascertain student perceptions of o-b-e for the time periods of 2011 and 2012. This is due to the fact that it was only made available online for the first time during 2011. The questionnaire comprised three open and seven closed ended questionnaires which result in both quantitative and qualitative data. Student achievement, in terms of their final grade marks, is used as a reference to determine the efficacy of o-b-e in this telecommunications module.

5. Student success rates for both closed book and open book examinations

Student pass rates (number of students obtaining 50% or more for their final grade mark) for the module are shown in Fig. 1, where the results in light grey represent UNISA while those in dark grey represent VUT. The average pass rate for VUT during the 2003 through 2005 period was 69% for c-b-e, with a low point occurring in 2005. The average pass rate for UNISA between 2007 and 2010 was 37% for c-b-e, with a low point occurring in 2008. The average pass rate for o-b-e at VUT was 87% (2007 through 2012) and for UNISA it was 45% (2011 and 2012). These results show that more residential contact students pass this telecommunications module than open distance learning students. This may be due to the fact that they are constantly in-contact with their lecturer, study material and study support groups. The results also show that o-b-e has resulted in a higher pass rate than c-b-e for students at VUT, while no such deduction can as yet be made for students at UNISA.

6. Results of the questionnaire to ascertain student perspectives on open book examinations

Qualitative data analysis was done on three of the 10 questions asked in the questionnaire at the beginning of the semester. These three questions were open ended questions, allowing students to answer freely

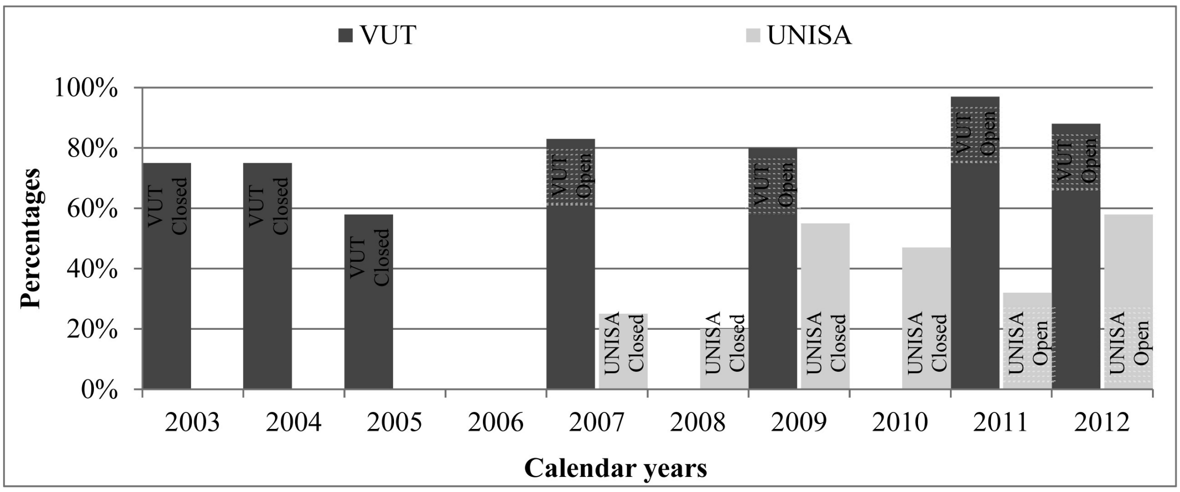

Fig. 1. Student success rates for Satellite Communications IV—both Universities.

Table 3. Qualitative analysis of two open ended questions

Question 1		
What do you think of when you hear the phrase "open book examination"?	**2011**	**2012**
It is difficult / tough	5	6
It enables copying from the textbook	4	0
Test student understanding	3	2
Moves away from memorizing a lot of work	3	2
Scares me / makes me uneasy	2	2
Test the application of knowledge	1	2
Helps with life-long learning	1	0
Focuses more on the practical side	1	0
Makes reference to the work environment	1	0
Need to be well prepared	0	6

Question 2		
How do you personally feel about open book examinations?	**2011**	**2012**
I think its okay / good	7	6
Wasting time finding answers	4	0
Depends on the subject in question	2	0
Have to know where in the book the work is	2	0
Acceptable if the questions are relevant	1	1
Teaches organization and preparation	1	2
Preferrable with a heavy workload	1	3
Confusing and challenging	1	0
Do not like examinations	0	1

Table 4. Reasons and benefits of using open book examinations

Question 3		
What reasons could you think of for allowing open book examinations?	**2011**	**2012**
Subject with a heavy workload	7	5
Application of knowledge	5	4
Subject with long calculations	2	5
Problem solving	2	0
Subject is too difficult	1	1
Creative thinking	1	0
Logical reasoning	1	0
Encourages more reading	0	3

Question 4		
Please indicate which benefits result from using open book examinations?	**2011**	**2012**
Less memorizing required	20	16
More room for logical reasoning	14	9
More room for creative thinking	13	7
Less stressful	6	7
Less time consuming for preparation	3	5

based on their own perceptions. Table 3 presents the qualitative analysis of two of the open ended questions (Question 1 and 2) with respective to student responses for 2011 and 2012 from both Universities (the questionnaire was used for the first time in 2011 with an online learning management system).

The right hand columns show the number of students who mentioned these responses, with the majority of students feeling that o-b-e are okay/good. A number of students indicated that o-b-e test student understanding while moving away from memorizing a lot of work. Other noteworthy statements include helping with life-long learning, focusing on the practical side and the need to be well prepared. These responses were collected from students at both universities, with very little difference between their responses. Some students from both institutions did not complete the questionnaire! Table 4 illustrates the responses of students with respect to two other questions, one being open ended (Question 3) and the other close ended (Question 4). These questions probed student thoughts with regard to reasons and benefits of using o-b-e. Figure 2 further highlights four closed ended questions where almost 50% of the respondents indicated that they would prefer o-b-e, while almost 60% of the respondents disagree that it calls for less preparation.

The results in Table 4 show similar student perceptions for 2011 and 2012. A striking comment by many students is that the use of o-b-e should be applied to modules with a heavy workload, where the emphasis must be on testing application of knowledge. This coincides with the second ELO specified by ECSA, namely the application of scientific and engineering knowledge. Many students also indicated a number of benefits in using o-b-e, which include less memorizing (also established in the literature) and more room for logical reasoning. These benefits are extremely important to students with particular learning styles, such as inductive learners who learn by logical thinking and visual learners who learn by seeing [41].

7. Discussions

Disadvantages, as deduced from the literature, of o-b-e include not using it to test the recall of information and the additional effort that academics must put forth to help students change their study habits with regard to this type of assessment. Notable advantages, from the literature, include more emphasis being placed on the application of knowledge that has a significant turnover rate, forcing academics to engage more with the course literature on a constant basis when setting examinations,

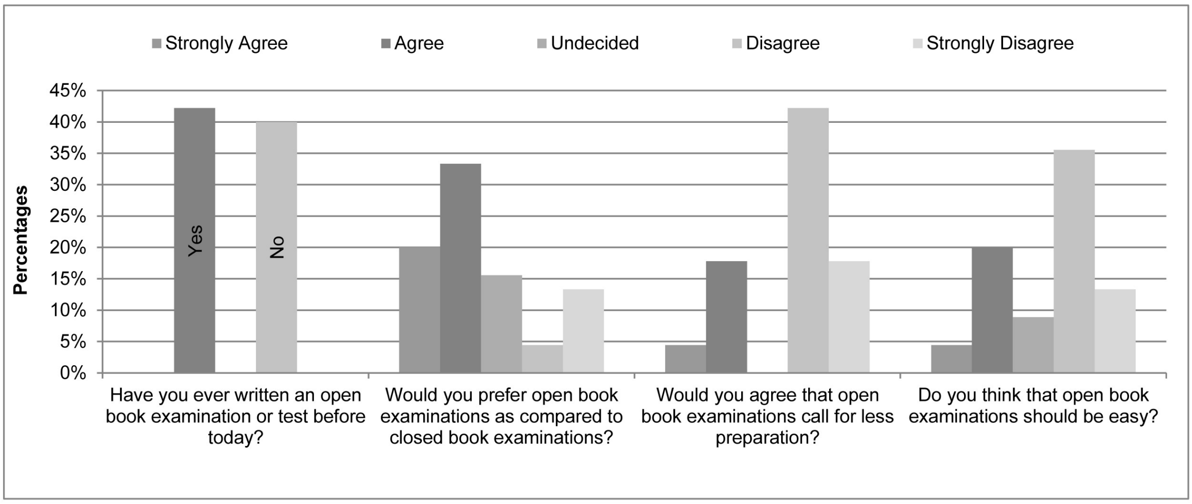

Fig. 2. Responses of students to closed ended questions.

forcing students to purchase and read the required material, encouraging students to make notes which they understand in their prescribed material, and proves beneficial for students who experience memory difficulties. Significant applications of o-b-e include modules that call for solutions to real-life problems found in Industry, lengthy design questions involving numerous calculations and the application of scientific and engineering knowledge to benefit a specific community or organization.

A high pass rate in a telecommunications module at a residential contact university has been maintained using o-b-e, while student perceptions indicate that o-b-e test student understanding, promote life-long learning and should be used in modules with heavy workloads. The case study further showed that 40% of the enrolled students had never written an o-b-e before (see Fig. 2). This suggests that many academics are reluctant to use this form of assessment, maybe having the perception that it leads to copying or plagiarism. However, if an o-b-e is implemented correctly with academics putting forth more effort in setting high order level questions, then this form of assessment may prove significant in helping students become life-long learners. Students indicated that o-b-e are not easy and does require more preparation than a c-b-e, but would be preferred by engineering students enrolled for this telecommunications module.

8. Conclusions

A limitation of this study is that student feedback was only obtained for two years of data, while the use of o-b-e has been used for a longer time. A longer time-lag study, using different students from different registration years in the same course structure, could produce more reliable data. Another limitation of the study is that this telecommunications module was only introduced at UNISA in 2007, while it has been offered at VUT since 2003. VUT has therefore had more time to identify and rectify any course deficiencies which they may have encountered with their first cohort of students, which UNISA may still be doing.

The purpose of this article was to highlight the advantages and disadvantages of o-b-e while categorizing its application in higher education. O-b-e was implemented in a telecommunications module at two vastly different universities and student feedback was sought at the end of the course. More than 80% of students from a residential contact university passed their o-b-e, while less than 60% of their counterparts from an open distance learning institute achieved this same objective. Student feedback via an online questionnaire highlighted that the majority of these students would prefer o-b-e as compared to c-b-e.

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Arthur James Swart obtained his DTech: Electrical: Engineering from the Vaal University of Technology in 2011, and his Masters in Education in 2008. At present, he is a Part-time Lecturer in the Department of Electrical and Mining Engineering at UNISA and an Associate Professor at the Central University of Technology. His research interests include the application of photovoltaic panels and engineering education with special emphasis on fusing theory and practical in the teaching and learning process.

Trudy Sutherland obtained her PhD in 2009 from the Stellenbosch University and her MTech: Electrical: Engineering in 2004 from the Vaal University of Technology. Her professional interests include electronic design, academic development and curriculum studies. She is currently managing the University's pre-diploma programmes, which has proved very successful in helping students enter and succeed in the mainstream programmes of Engineering.