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Analysing learning outcomes in an Electrical Engineering curriculum using illustrative verbs derived from Bloom's Taxonomy

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ABSTRACT
Learning outcomes are essential to any curriculum in education, where they need to be clear, observable and measurable. However, some academics structure learning outcomes in a way that does not promote student learning. The purpose of this article is to present the analyses of learning outcomes of an Electrical Engineering curriculum offered at a University of Technology in South Africa, in order to determine if academics are structuring them in a way that enables student learning. A qualitative case study is used where the learning outcomes from 33 study guides are reviewed using illustrative verbs derived from Bloom's Taxonomy. Results indicate that 9% of all the learning outcomes are unclear, 10% are unobservable and 23% are unmeasurable. A key recommendation is to provide regular workshops to assist academics in reviewing their learning outcomes using the illustrative verbs derived from Bloom's Taxonomy, thereby ensuring that their learning outcomes promote student learning.

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Poorly structured; qualitative; unclear; surface learning

Introduction

'I am always doing that which I cannot do, in order that I may learn how to do it' (Pablo Picasso n.d.). These words, by Pablo Picasso, a famous Spanish artist of the twentieth century, clearly indicate that learning is fundamental to master that which one could not originally accomplish. However, setting out to accomplish something which is ill-defined can prove cumbersome and frustrating. This is especially so for freshman engineering students in higher education who may encounter learning outcomes (that which they must master or accomplish) that are ambiguous, unmeasurable, unmanageable and unreasonable.

Learning outcomes are at the centre of learning in numerous institutions of Higher Education. All the members of the Association of American Colleges and Universities (AACU) have adopted the use of learning outcomes in all their modules (Hart Research Associates 2016). In the South African context, the South African Qualifications Authority (SAQA) prescribes the use of learning outcomes as a framework for teaching and learning in universities (SAQA 2012). In spite of the fact that learning outcomes are at the centre of Higher Education learning, there is limited scholarship about how they are used by educators and students (Hadjianastasis 2016).

Dobbins et al. (2016) contend that despite detailed literature exploring the advancement of a learning outcomes approach in higher education, limited evidence exists concerning academics' use of them. Several studies have been done regarding learning outcomes; Henrichsen and

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Tanner (2011) considered the creation of learning outcomes; Boniface, Read, and Russell (2011) focused on sharing learning outcomes in teaching and Dobbins et al. (2016) explored academics' views and uses of learning outcomes. Few research studies consider analysing learning outcomes in terms of Bloom's Taxonomy, in order to understand whether academics develop them in a way that is clear, observable and measurable. This study seeks to bridge this perceived gap in the literature.

The purpose of this study is to present the analyses of learning outcomes of an Electrical Engineering curriculum offered at a University of Technology in South Africa in order to determine if academics are structuring them in a way that enables student learning. The study begins by conceptualising learning outcomes in terms of how they are defined, how they differ from aims and objectives and what their fundamental purpose in education is. This paper then introduces the theoretical framework, the context of this study and the research methodology. Results are presented in the form of tables and graphs, with separate discussions linking the results back to the literature of the study. Succinct conclusion completed the paper.

Conceptualisation of learning outcomes

Although there is no universally accepted definition of learning outcomes, various meanings exist that point to them as statements of what a student is expected to know by the end of a programme, module or course. Kennedy (2007, 21) defines learning outcomes as 'statements of what a student is expected to know, understand and/or be able to demonstrate after completion of a process of learning'. Similarly, Melton (2012) argues that learning outcomes are statements of desired results of learning expressed in a way that explicitly shows what a student must be able to do. Learning outcomes can be conceptualised from the perspective of knowledge, skills and attitudes. Suskie (2004) and the University of Toronto (2008) consider learning outcomes as statements which describe the knowledge, skills or attitudes which students should acquire by the end of a particular assignment, class, course or programme. Simply stated, learning outcomes describe two key aspects: what educators want students to know and what educators want students to be able to do (Brooks et al. 2014).

What a student is expected to know and to be able to do must be captured in learning outcomes (O'Brien and Brancaleone 2011). Thus one of the fundamental purposes of learning outcomes is to guide student learning. A study conducted by Dobbins et al. (2016) found that 84% of Biological Science educators indicated that learning outcomes are useful learning aids for students. They enable students to precisely know what is expected from them within a particular module. Hadjianastasis (2016) and Dobbins et al. (2014) maintain that learning outcomes provide useful guidance to enable student learning while also enabling educators to plan and organise their teaching practice. They therefore assist educators to remain focused on what they want their students to achieve (Chance and Peck 2015). Employers also benefit from well-structured learning outcomes, as external evaluators may easily determine what knowledge and attributes have graduates from a particular institution attained (O'Brien and Brancaleone 2011; Fiegel 2013). Scholars have different views pertaining to conceptualisation of aims, objectives and outcomes of learning (Kennedy 2007; Khoza 2013).

Aims, objectives and outcomes of learning

Aims are different from objectives and outcomes. Aims are broad general statements of the teaching intention (Kennedy 2007). They indicate in broad perspectives what educators intend to cover in a module. For example, the aim of a module may be to introduce students to electronic components. However, which components must be introduced and where should these components be applied would be written into the learning objectives of that module. The aim of a module therefore provides a broad purpose or general teaching intention, while the objective gives more specific information about what the teaching of the module hopes to achieve (Kennedy, Hyland, and Ryan 2006; Kennedy 2007; Biggs 2012).

Scholars are divided when it comes to differentiating between learning objectives and learning outcomes, as they make no distinction between them but rather use them interchangeably (Baldizan and McMullin 2005; Welch, Ressler, and Estes 2005; Fiegel 2013). According to the University of Toronto (2008, 3), 'the distinction between learning outcomes and learning objectives is not universally recognised, and many instructors may find that the term "learning outcomes" describes what they have already understood by the term "learning objectives"'. However, Kennedy, Hyland, and Ryan (2006) make a distinction between learning outcomes and learning objectives as the former being a subset or type of the latter. In other words, learning outcomes are developed after the learning objectives have been formulated. Learning outcomes therefore become very precise and clear when compared to learning objectives.

Although the University of Toronto (2008) views learning outcomes and objectives as one and the same, it argues that academics that differentiate between the two do so by looking at it from different perspectives. Learning objectives would be focusing on outlining the material which an educator intends to cover, while learning outcomes would be focusing on what students should know and be able to do by the end of a course (University of Toronto 2008; Brooks et al. 2014). Khoza (2013) concurs that on one hand, learning objectives are generated according to the educator's intentions while learning outcomes are presented in terms of what students must do. For example, a learning objective may be that educators want students to understand the operation of power supply units in a course on Electronics. However, a learning outcome would be that students need to sketch and explain the block diagram of a 12-V power supply unit.

It is not very clear why learning objectives would be developed with a focus on educators rather than students. That lack of clarity brings confusion among students and educators (University of Toronto 2008). Moon (2002) concurs that objectives written with a focus on educators often confuse both students and educators themselves. In order to avoid confusion, which is often created by an attempt to differentiate learning objectives and learning outcomes, this study conceptualises the two as one and the same thing. The two (learning outcomes and learning objectives) are expected to be written with action verbs which are clear, observable and measurable. In order to ensure consistency, learning outcomes are going to be used throughout this study. The same goals addressed by learning objectives can be equally addressed by learning outcomes (University of Toronto 2008; Hassan 2011; Fiegel 2013).

In spite of differences among scholars on distinguishing between learning outcomes and objectives, they unanimously agree on a view that effective outcomes should have certain characteristics. Swart (2014) postulates that effective learning outcomes need to be clear, concise, measurable, manageable, reasonable and sustainable. Similarly, Chance and Peck (2015) contend that the most effective learning outcomes provide specific, observable and measurable evidence of student learning and growth within a program. As much as possible, learning outcomes should be crystal clear, observable and measurable (Khoza 2013). Clarity, observe-ability and measurability are recurring characteristics that every good learning outcome must have. If those fundamental characteristics do not occur, then students are more likely to fail. About 40% of students failed a computer literacy course due to the fact that some outcomes were not clear, observable and measurable, according to Khoza (2001). Learning outcomes which are ambiguous and unmeasurable are almost always associated with negative evaluations, learning difficulties and poor student performance (Kennedy, Hyland, and Ryan 2006).

Development of clear, observable and measurable outcomes marks the departing point in the design of a sustainable curriculum (Boniface, Read, and Russell 2011) as vague learning outcomes hamper effective teaching and learning (Swart 2014). Having clear, observable and measurable learning outcomes have a fourfold advantages: (i) students know unambiguously what they are expected to do in a module (Dobbins et al. 2016); (ii) it simplifies the process of developing assessment measures (Fiegel 2013); (iii) it promotes deep learning (Biggs 2003) and (iv) if an academic lecturing a specific module had to leave the services of the university or become seriously ill, his or her successor would be able to take over the module with the minimum amount of stress or uncertainty (Swart 2014).

Developing clear, observable and measurable learning outcomes really requires the use of illustrative verbs which are clearly understood by all stakeholders. Illustrative verbs, such as define, explain, apply, calculate, design, analyse, evaluate and create, unambiguously enable students to know exactly what is expected of them in a given module. It must be emphasised that writing learning outcomes that are clear, observable and measurable using a range of illustrative verbs requires reflective thinking on the part of an educator, which in turn requires effort. However, it is beneficial to all stakeholders and especially to educators who may now easily design and evaluate specific assessments that are directly linked to the learning outcomes (Biggs 2012). There is a need for clear illustrative verbs excluding understand, know, learn, be aware of, be exposed to and appreciate, as they are less easily understood and more difficult to assess (Chance and Peck 2015, 410). They are not observable and very difficult to measure. In fact, the verb 'understand', which is often used as a cornerstone for many learning outcomes, does prove problematic (Larkin and Richardson 2013), fuzzy, unmeasurable and does not really provide conditions for success (Chance and Peck 2015, 410).

Learning outcomes of any curriculum need to be analysed with regard to the three fundamental requirements identified in this discussion, being clear, observable and measurable. One technique of doing this is by using the illustrative verbs defined for the different levels of Bloom's Taxonomy that is used as the theoretical framework for this study.

Theoretical framework

The theoretical framework guiding this study is based on the different levels of Bloom's Taxonomy. It was developed by Benjamin Bloom in 1956 and revised in 2001 (Anderson and Krathwohl 2001). Bloom's Taxonomy provides a hierarchy of increasingly complex cognitive functions which ranges from lower levels (basic recall of information) to higher levels (logical reasoning and critical thinking). Six cognitive levels were originally stipulated with knowledge being the lowest and evaluation being the highest level. The two lower levels (knowledge and comprehension) promote lower order thinking while the next four levels (application, analysis, synthesis and evaluation) promote higher order thinking (Swart 2010). Knowledge and comprehension are often associated with verbs such as define and discuss. A verb associated with application is often calculate, with analysis it is distinguish, with synthesis it is combine and with evaluate it is conclude. Students are likely to learn effectively and become critical thinkers if they are exposed to the full range of the Bloom's taxonomy. The original objectives are contrasted to the revised ones in Table 1, where the illustrative verbs and levels are derived from research done by Swart (2010).

The main difference between Bloom's original Taxonomy and the revised one is the renaming of a number of levels; evaluation becomes creating, synthesis becomes evaluating, comprehension becomes understanding and knowledge becomes remembering (Anderson and Krathwohl 2001). According to Green (2010), a revision of Bloom's Taxonomy, which was led by one of Bloom's original co-authors, was done in order to make instructional tasks and assessment activities easier to design. The revised taxonomy also presents each cognitive activity as a verb, indicating the action that a learner is expected to demonstrate. This makes it easier for educators to write learning outcomes which are clear, observable and measurable (Biggs 2012).

Bloom's Taxonomy was chosen as the most appropriate framework for this study as it has been noted to be the best starting point for writing learning outcomes (Kennedy, Hyland, and Ryan 2006; Fiegel 2013). It is globally used by educationalists and provides a ready-made structure of appropriate illustrative verbs which educators can use in order to measure student learning (Hadjianastasis 2016). Bloom's Taxonomy was also chosen for this study as many universities have adopted this taxonomy as a means of evaluating their final examination papers in order to ensure that students are assessed with regard to the right graduate attributes (Central University of Technology

Table 1. Revised Bloom's Taxonomy with appropriate synonyms and illustrative verbs.

Original objective	Revised objective	Definition	Synonyms	Illustrative verbs	Levels
Evaluation	Creating	Creation or development of something	Creation Combining	Create, assemble, construct, design, develop, formulate	Highest level dependent on students reasoning ability
Synthesis	Evaluating	Judging the value of the system based on given criteria	Judgement Assessment	Justify, criticise, conclude, evaluate, verify, confirm, determine, analyse	Higher level
Analysis	Analysing	Breakdown of a system into its elements/parts	Study Scrutiny Breakdown	Analyse, appraise, distinguish, compare, contrast, differentiate, classify, categorise, experiment	Higher level
Application	Applying	The use of abstractions in particular and concrete situations	Use Purpose Apply	Apply, develop, demonstrate, modify, solve, use, show, calculate, compute	Higher level
Comprehension	Understanding	Translation, interpretation and extrapolation of elements/parts	Understand Grasp	Explain, convert, estimate, rearrange, summarise, derive, review, relate	Lower level
Knowledge	Remembering	Recall or recognition of specific elements/ parts	Information Facts Data	Name, label, list, state, define, describe, order, outline, relate, repeat, discuss, identify, select, insert, complete, label	Lowest level dependent on students' memory ability

[CUT] 2016; University of South Africa [UNISA] 2016). CUT (2016) expects lecturers to articulate clear study guides containing illustrative verbs from Bloom's Taxonomy. The institution conforms to Blooms' Taxonomy so much such that study guides with learning outcomes which do not have verbs consistent with the theory are labelled poor as they will be ambiguous, unmeasurable and unobservable.

One technique of analysing whether learning outcomes are clear, observable and measurable involves the use of illustrative verbs defined for the different levels of Bloom's Taxonomy (Swart 2014). This was done for the curriculum of the National Diploma: Engineering: Electrical which forms the context of this study.

Context of this study: National Diploma: Engineering: Electrical

The National Diploma: Engineering: Electrical requires students to obtain a minimum credit value of 360 (which equates to 3600 notional hours of study) and is currently a National Qualifications Framework (NQF) level 6 qualification. The purpose of the qualification is to build the necessary knowledge, understanding and skills in a student so that he/she may progress towards becoming a competent practising engineering technician (Central University of Technology [CUT] 2016). Students may choose from 36 modules within this qualification (each with its own credit value) to accumulate a minimum of 240 credits. However, nine modules are compulsory for all specialisations and are shown in Table 2, where the modules termed computer and communication skills have six credits awarded to them. Students are further required to complete at least five exit level modules (e.g. Design Projects III, structure described by Swart, Lombard, and De Jager 2010; Mathematics III; Power Electronics III; Logic Design III and Radio Engineering III, structure described by Swart 2014). A compulsory Work Integrated Learning module (credit value of 120) must also be completed. The Department of Higher Education and Training in South Africa stipulates a minimum study period of 3 years and a maximum study period of 6 years. Students have the option to specialise in power electronics, control systems, signal processing or telecommunications (Hertzog and Swart 2015). These specialisations would require students to complete a specific sequence of approximately

Table 2. Compulsory modules in the National Diploma: Engineering: Electrical curriculum.

Module	Credits	Purpose of the module
Computer skills	6	Introducing students to computer literacy
Communication Skills I	6	A fundamental module aimed at refining students' oral and academic writing skills
Electrical Engineering I	12	Introducing students to electrical engineering concepts and techniques
Electrical Engineering II	12	Let students analyse, design, construct and apply electronic devices in the power engineering field
Electronics I	12	Introduces students to the analysis and design of electronic circuits. The module is a foundation to other more advanced electronic courses
Electronics II	12	Enabling students to design, analyse, build and construct electronic circuits
Mathematics I	12	To introduce students in the engineering fields to several mathematical methods that are essential to the successful solution of real problems that will be encountered in several areas of engineering applications
Mathematics II	12	To introduce students in the engineering fields to several mathematical methods that are essential to the successful solution of real problems that will be encountered in several areas of engineering applications
Design Projects III	12	Equipping students with knowledge about logic designs and software, and project proposal writing skills

20 modules out of the available 36. The National Diploma includes both theoretical and practical instructions where students can demonstrate vital graduate attributes within a laboratory environment (Luwes and Swart 2015). A person in possession of this qualification (National Diploma: Electrical: Engineering) is able to work in the South African engineering environment and to register with the Engineering Council of South Africa as a candidate Engineering Technician (CUT 2016).

Methodology

This study uses a qualitative approach within an interpretivist paradigm. A qualitative approach was chosen as it is compatible with a documentary review that was used in this study. Documentary review refers to a systematic process of analysing written texts that contain information about the phenomenon under study (Bailey 1994). A qualitative approach further enables researchers to generate rich textual data from reviewed documents. An interpretivist paradigm was preferred as it is compatible with a qualitative approach. An interpretive paradigm is a philosophical assumption which aims to understand a particular phenomenon (Neuman 2011). It has been used in social sciences research to understand and describe meaningful social actions (Schultz and Hatch 1996). Lapan, Quartaroli, and Riemer (2012) argue that all qualitative research has an interpretive perspective which focuses on understanding and interpreting meaning of a phenomenon.

This study focused on the National Diploma: Engineering: Electrical curriculum offered by the Department of Electrical, Electronic and Computer Engineering at the Central University of Technology (CUT) in South Africa. A case study is usually used to increase the understanding of certain complex phenomena (Rahim and Chik 2014). In this study, the phenomenon is to analyse learning outcomes to determine the extent to which educators conform to the institution's recommended theory of Bloom's Taxonomy. According to Punch (2009), a case study further aims to understand a case in depth, recognising its complexity and context. Criteria for sampling in case studies are usually purposeful with an emphasis on those cases that seem to offer opportunities to learn (Hall, Scott, and Borsz 2008).

Data was collected using documentary review. This method is efficient and more cost effective than social surveys, in-depth interviews or participant observations (Mogalakwe 2006). Documents reviewed in this study were 33 out of the 36 study guides used in the National Diploma: Engineering: Electrical curriculum. Three lecturers did not want their study guides to be analysed and so did not provide them to the researchers.

The criteria for rating/scoring the learning outcomes are based on the use or non-use of illustrative verbs that inform the six cognitive levels of Bloom's Taxonomy which the Central University of Technology has adopted (categories were drawn from the illustrative verbs given in Table 1). Any learning outcome that does not include an illustrative verb is deemed unclear, not observable and unmeasurable (poorly structured). Illustrative verbs may also be termed 'action verbs' that connote a measurable behaviour (Willems 2016). Consider, for example, the following learning outcome 'Understand the requirements for insulators' that was found in one of the study guides. The learning outcome is unclear, as the student does not know how he or she should demonstrate their understanding. It is not observable, as the student is not required to demonstrate anything specific in this regard. It is also unmeasurable, as one cannot measure understanding in this regard. The word 'understand' is not an illustrative verb. It could be rephrased 'Understand the requirements for insulators by compiling a data table'. This is now measureable and observable, as the student knows that he or she will be required to compile a table showing the key parameters of an insulator, thereby demonstrating their understanding of the requirements. Another example that was found in a different study guide states 'Appreciate the use of complex numbers in a.c. circuits'. What must the student physically do? This is unclear. What must the student demonstrate? This is not observable and is unmeasurable. It is usually stated that, on completion of a learning unit, students will be able to do something. The word 'appreciate' is not an illustrative verb. Students cannot form a picture in their heads about what is going on as it could simply mean clap, smile, thank or even verbally express appreciation (Greer et al. 2014). It could be rephrased as follows, 'Appreciate the use of complex numbers in AC circuits by calculating its real and imaginary values'. Well-structured and poorly structured learning outcomes were identified. A well-structured learning outcome included one illustrative verb that may be correlated to Bloom's Taxonomy, clearly conveying to students what is expected of them. A poorly structured outcome was identified when the learning outcome had no illustrative verb, making it challenging to determine what students should be able to do at the end of the unit or module.

The rating/scoring was done by the authors, who have published numerous articles focusing on learning outcomes and illustrative verbs taken from Bloom's Taxonomy, with the most recent one discussing the importance of setting clear, observable and measurable learning outcomes (Swart 2014). The authors have also facilitated numerous workshops at international conferences since 2008 on the importance of academic's maintaining a proper balance between higher order and lower order questions using Bloom's Taxonomy. Both authors individually rated the learning outcomes in the various study guides, recording the number of well-structured or poorly structured learning outcomes in an EXCEL sheet, after which an inter-rater reliability score was established. Inter-rater reliability is a measure of reliability that is employed to assess the degree to which different judges or raters agree in their assessment decisions (Ghadi 2016). Inter-rater reliability coefficients should be between 0.7 and 0.9 depending on the level of importance of the decision-making process (Kelly 1927). In this study, an inter-rater reliability score of 91% was attained (Pearson correlation of 0.911). There was no bias in rating/scoring the outcomes.

It must be emphasised that the study guides, as a whole, must have learning outcomes developed using illustrative verbs covering all six levels stipulated by Bloom's Taxonomy which the institution recommends. Data was recorded in a matrix contrasting the different modules in terms of their total number of learning outcomes and whether they are well or poorly structured, as presented in the following section.

Findings

Findings of this study suggest that the National Diploma: Engineering: Electrical curriculum comprises a mixture of both well-structured and poorly structured learning outcomes (see Figure 1). The curriculum has a total of 686 learning outcomes, of which 400 (58%) were deemed to be well-structured, containing illustrative verbs from Bloom's Taxonomy informing students what they should be able to

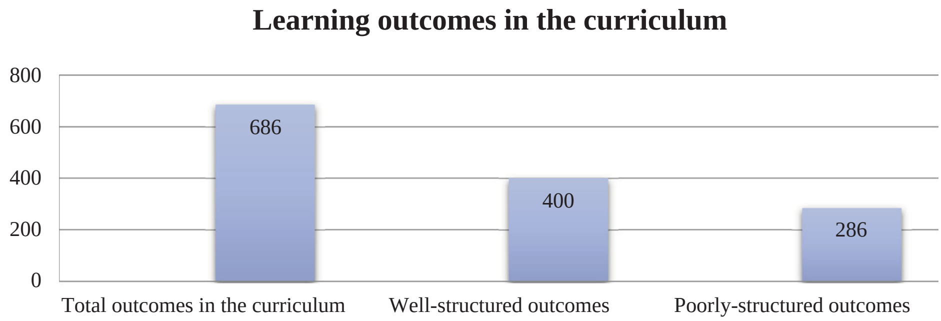

Figure 1. Total learning outcomes in the National Diploma: Engineering: Electrical curriculum.

do. The remaining 286 learning outcomes (42%) were deemed to be poorly structured; giving a vague idea of what students should do in the module.

Outcomes which are classified as well-structured are consistent with the illustrative verbs used in Bloom's Taxonomy, being clear, observable and measurable, clearly conveying to students what is expected of them. Consider the following three examples: 'Students should be able to:'

- State Kirchhoff's voltage and current laws
- Explain the difference between conductors, semi-conductors and insulators
- Calculate mass flow rate of cooling water through condensers.

Note, especially the second learning outcome listed above, starting with the verb 'explain'. On its own, the verb 'explain' may be used as a broad term. However, in this context it is narrowed down by the lecturer who wants students to explain the difference between various materials. This enables the student to have a clear mental image of what is really required.

Poorly structured outcomes consist of words or phrases which are unclear, unobservable and unmeasurable. For example, one module had the largest number of poorly structured outcomes, being 100% of the stated 28 learning outcomes. Learning outcomes consistently featured the phrase 'by the end of the module, students should be able to understand, gain acquaintance and become familiar with'. The verb 'understand' was found in the majority of the 28 learning outcomes. How would this understanding be demonstrated by the students? This key aspect led to these outcomes being labelled as unclear, unobservable and unmeasurable. Furthermore, some of the modules have learning outcomes which feature NO verbs at all. Examples of poorly structured learning outcomes include: 'Students should'

- Gain acquaintance with the concept of transformer tap changing using ac controllers
- Understand principles of electronic design process
- Understand principles and practices of frequency modulation and demodulation.

Consider the first learning outcome listed above. The verb 'gain' simply means to obtain and the noun 'acquaintance' refers to a person's knowledge or experience. So, this may be interpreted as students needing to obtain a general knowledge or experience on the concept of transformer tap changes using ac controllers. The fundamental question resides 'How will this experience be assessed?' It really becomes unobservable and unmeasurable. An alternative clear and measurable rendering of this learning outcome may be 'Describe the process of transformer tap changing using ac controllers'. This narrows the requirement down to the process involved and not just to a general knowledge of the concept. The most occurring verbs are shown in Figure 2 while Figure 3 shows the matrix of learning outcomes.

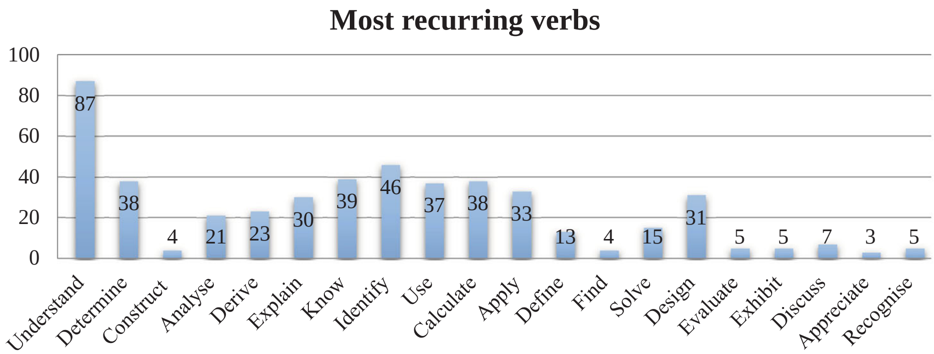

Figure 2. Most recurring verbs in the learning outcomes of the curriculum.

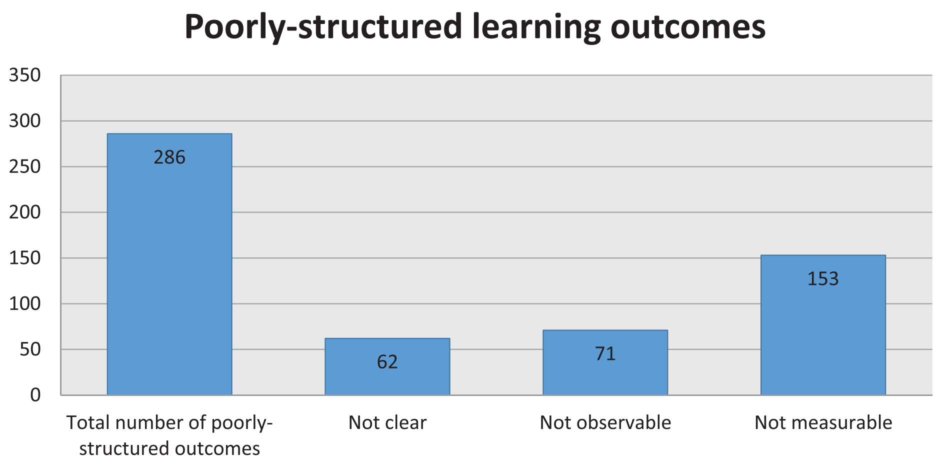

Figure 3. Histogram of poorly structured learning outcomes.

In Figure 2, the most recurring verbs include understand (87), identify (46), know (39), calculate and determine (38), use (37), apply (33), design (31) and explain (30). Many of these verbs promote lower order thinking (understand, identify and explain). Some of the recurring verbs, such as 'know' and 'use' are tantamount to the word understand, which is very difficult to observe or measure accurately.

In Table 3, learning outcomes for 33 of the 36 study guides are presented. The remaining three study guides (Mechanics I, Communication Skills I and Computer Skills 1) were not provided by the lecturers for the analysis. Only one module was found to have 100% clear, observable and measurable learning outcomes, being Electrical Engineering I. Five modules were found to have learning outcomes which lack all three requirements, being unclear, unobservable and unmeasurable. These are Control Systems III, Digital Systems I, Digital Systems III, Software Design II and Mechanical Technology I. The proportion of poorly structured learning outcomes (subdivided into the three key requirements: being clear, observable and measurable) is shown in Figure 3.

Sixty-two (22%) learning outcomes were determined to be unclear. They do not vividly indicate to students what they are supposed to be able to do at the end of the module. For example, one of the learning outcomes stated:

> By the end of the learning unit, a student is being introduced to typical problems in practice for example the design and production of a complete system, the solution of a problem by a constructed project the assembling

Table 3. Outcomes in the National Diploma: Engineering: Electrical curriculum.

Num.	Module	Total outcomes in each module	Well-structured outcomes	Poorly structured outcomes	Not clear	Not observable	Not measurable
1	Applied Strength of Materials III	24	13	11	11	–	–
2	Control Systems III	36	25	11	5	2	4
3	Digital Systems I	13	5	8	1	6	1
4	Digital Systems II	18	10	8	–	6	2
5	Digital Systems III	17	10	8	4	2	2
6	Electrical Distribution III	37	22	15	–	1	14
7	Electrical Engineering I	22	22	–	–	–	–
8	Electrical Engineering II	55	42	13	–	2	11
9	Electrical Engineering III	35	17	18	–	2	16
10	Electronic Applications III	13	9	4	–	1	3
11	Electronic Communication II	5	3	2	–	–	2
12	Electrical Machines II	17	11	6	2	–	4
13	Electrical Machines III	15	12	3	2	–	1
14	Electrical Protection III	34	26	8	2	–	6
15	Logic Design III	10	6	4	4	–	
16	Power Electronics III	28	0	28	2		26
17	Projects I	5	0	5	–	–	5
18	Projects II	15	4	11	–	11	–
19	Software Design II	49	12	37	10	18	9
20	Design Project III	19	7	12	–	12	–
21	Electronics I	21	18	3	–	1	2
22	Electronics II	16	14	2	–	1	1
23	Electronics III	16	13	3	–	–	3
24	Industrial Electronics II	27	8	19	–	1	18
25	Mathematics I	4	3	1		1	–
26	Mathematics II	17	15	2	2	–	–
27	Mathematics III	15	14	1	1	–	–
28	Mechanical Technology I	29	15	15	9	2	4
29	Mechanical Technology II	23	18	5	–	–	5
30	Mechanical Technology III	9	0	9	–	–	9
31	Radio Engineering III	5	0	5	–	–	5
32	Strength of Materials II	20	12	8	6	2	–
33	Strength of Materials III	17	14	1	1	–	–

and the putting into operation of a section or a complete working system, the manufacture and solving of problems in other faculties.

Not only is this learning outcome ambiguous, it is also too long, leaving students perplexed as to what is really required of them. In simple terms, the learning outcome is very unclear as it makes use of so many variables and verbs.

Seventy-one learning outcomes (25% of the poorly structured learning outcomes) were determined to be unobservable. An outcome which is not observable is structured without an illustrative verb or action word which makes it easy for students to understand what is expected of them. An example from one of the modules stated: 'On completion of this learning unit, students should be able to provide advanced background to the study of Design Project'. Such a learning outcome is not observable as it is too broad, making it difficult for educators to really assess specific student learning or attributes.

Of the 286 poorly structured learning outcomes, 153 (53%) are unmeasurable. In this case, educators may not be able to accurately measure student learning or ascertain if student learning has actually occurred. These learning outcomes often use the common phrase, 'by the end of the module, students should be able to', along with some of the following verbs: understand, tolerate, comprehend, get acquainted with, appreciate, become familiar with and realise. Some of these verbs suggest an inner feeling or emotion (such as tolerate and appreciate), which is very difficult to accurately assess at times.

Discussion

A critical analysis of learning outcomes in the National Diploma: Electrical: Engineering curriculum indicates that only one module (2.7%) adheres to the illustrative verbs in Bloom's Taxonomy, which the university uses as a guiding framework for developing effective outcomes. Cowan (2009) argues that learning outcomes need to be meticulously selected so that they can be very clear, observable and measurable. If those three principles are not attached to learning outcomes, students' ability to learn becomes unattainable (Brooks et al. 2014; Chance and Peck 2015). Learning outcomes should be written with a single illustrative verb, thereby negating all ambiguity!

The verb 'understand', which was found most often in the learning outcomes of the 33 modules, is often used as a cornerstone for many learning outcomes (Larkin and Richardson 2013). This is despite the fact that it remains problematic when it is used as a verb in the writing of learning outcomes. Chance and Peck (2015) contend that it is fuzzy and does not explicitly state what students are supposed to do. It is furthermore ambiguous, unobservable and unmeasurable, be similar to verbs such as appreciate, familiarise and know, which are often used by educators (Kennedy, Hyland, and Ryan 2006; Khoza 2013).

Many of the learning outcomes include verbs such as understand, identify and explain which promote lower order thinking (Biggs 2012) or surface learning. In lower order thinking, students are expected to exercise simple recalling of information (Swart 2014). This is opposed to higher order thinking verbs (deep learning) such as evaluate and construct which require students to use their reasoning capacities (Fiegel 2013). A balance between these two levels of thinking must be attained, as it is vital to produce graduates with the right attributes that include numeracy, problem-solving, technological literacy and entrepreneurship, attributes associated with higher order thinking.

It is acknowledged that engineering educators may not be experts in the assessment of learning outcomes and should seek assistance where necessary (Palmer 2004). If they are not experts in the assessment of learning outcomes, then they may also not be experts in the design and development of learning outcomes. Additional assistance must, therefore, be made available to academics (especially new academics or junior lecturers and lectures) by means of regular workshops or consultations with educational experts. The focus of this assistance should be on formulating learning outcomes that are clear, observable and measurable, comprising a single illustrative verb as derived from Bloom's Taxonomy.

However, it is encouraging to see that the majority of all the learning outcomes (400 out of 686 which equates to 58%) are well structured. Brooks et al. (2014) and Clark (2002) argue that when majority of learning outcomes are up to standard, then effective teaching and learning is likely to take place. Consequently, the entire teaching and learning process of the National Diploma: Electrical: Engineering may not be hampered as only 42% of the learning outcomes are not up to standard (Dobbins et al. 2016).

Conclusion

The purpose of this study was to present an analysis of learning outcomes of an Electrical Engineering curriculum offered at a University of Technology in South Africa in order to determine if academics are structuring them in a way that enables student learning. The learning outcomes of the National Diploma: Electrical: Engineering curriculum at a University of Technology in South Africa was reviewed with regard to three key requirements: being clear, observable and measurable. These three requirements must be met as it will benefit both students (clearly know what is expected of them) and academics (clearly know what and how to assess). Results indicate that 42% of the 600 learning outcomes are poorly structured, where 9% are unclear, 10% are unobservable and 23% are unmeasurable. Five modules have learning outcomes which feature NO verbs at all, while another five modules miss all three of the learning outcome requirements.

If learning outcomes are not clear, observable and measurable, teaching and learning activities and assessment are likely to be off and that results in contrasting the constructive alignment which promotes quality teaching and learning. In order to ensure constructive alignment, it is recommended to make use of the illustrative verbs of Bloom's Taxonomy as discussed in this article. In this article, illustrative verbs underpinning each of the six levels of Blooms Taxonomy were used to determine which learning outcomes were clear, observable and measurable. Using these verbs as a starting point provides a fundamental base upon which educators can design, develop and review their learning outcomes.

This study recommends that all educators should be afforded capacity development workshops related to the writing of outcomes. Such workshops should target junior and assistant lecturers, who must still acquire much experience as educators in Higher Education. Bending the figurative 'tree' while it is still small will result in a sturdy strong experienced 'trunk' later on in life. Furthermore, even lecturers and senior lecturers should be required to attend at least one workshop over a given time period, as many academics in Engineering in South Africa often have no formal teaching qualifications. They are experts in their respective disciplines, but they lack an education component where they may be exposed to vital educational theories such as Bloom's Taxonomy.

Thoughts for future work include correlating the findings of this research regarding modules with well-structured and poor-structured learning outcomes to the student success rates in those modules. Future research can also consider the appropriateness of each learning outcome to the level of study (first year versus final year outcomes) within the curriculum.

Setting clear, observable and measurable learning outcomes may assist all students in Higher Education to eventually accomplish that which they could not originally do. It may also assist academics in accomplishing that which they wish to do, which is to enable ALL students to achieve academic success in their respective fields of study.

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References

Anderson, L. W., and D. R. Krathwohl. 2001. *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*. New York: Longman.

Bailey, K. 1994. *Methods of Social Research*. New York: The Free Press.

Baldizan, M. E., and K. M. McMullin. 2005. "Evaluation of Student Learning for an Engineering Graphics Course." *ASCE Journal of Professional Issues in Engineering Education and Practice* 131 (3): 192–198.

Biggs, J. 2003. *Teaching for Quality Learning at University*. Buckingham: Open University Press.

Biggs, J. 2012. "What the Student Does: Teaching for Enhanced Learning." *Higher Education Research & Development* 31 (1): 39–55.

Boniface, J., D. Read, and A. E. Russell. 2011. "Sharing Learning Outcomes in Chemistry Teaching at HE Level: Beneficial or Detrimental?" *New Directions*. Accessed 9 July 2016. https://www.heacademy.ac.uk/sites/default/files/ndir.1.7i.pdf.

Brooks, S., K. Dobbins, J. J. A. Scott, M. Rawlinson, and R. I. Norman. 2014. "Learning About Learning Outcomes: The Student Perspective." *Teaching in Higher Education* 19 (6): 721–733.

Central University of Technology, Free State (CUT). 2016. *Prospectus*. Accessed 14 September 2017. http://www.cut.ac.za/wp-content/uploads/2013/04/CUT-Prospectus-2016.pdf.
Chance, B., and R. Peck. 2015. "From Curriculum Guidelines to Learning Outcomes: Assessment at the Program Level." *The American Statistician* 69 (4): 409–416.
Clark, R. A. 2002. "Learning Outcomes: The Bottom Line." *Communication Education* 51 (4): 396–404.
Cowan, J. 2009. "Improving Students' Learning Outcomes." In *Improving Students' Learning Outcomes*, edited by C. Nygaard, C. Holthman, and N. Courtney, 9–16. Gylling: Copenhagen Business School Press.
Dobbins, K., S. Brooks, J. J. A. Scott, M. Rawlinson, and R. I. Norman. 2014. "Understanding and Enacting Learning Outcomes: The Academic's Perspective." *Studies in Higher Education*. Accessed 15 June 2016. http://staffblogs.le.ac.uk/loproject/2014/10/15/secondpaper/.
Dobbins, K., S. Brooks, J. J. A. Scott, M. Rawlinson, and R. I. Norman. 2016. "Understanding and Enacting Learning Outcomes: The Academic's Perspective." *Studies in Higher Education* 41 (7): 1217–1235.
Fiegel, G. L. 2013. "Incorporating Learning Outcomes into an Introductory Geotechnical Engineering Course." *European Journal of Engineering Education* 38 (3): 238–253.
Ghadi, S. A. 2016. "The Effect of Employing Electronic Peer Assessment on Iranian EFL Learners' Writing Ability and Autonomy." *Theory and Practice in Language Studies* 6 (12): 2272–2279.
Green, K. H. 2010. "Matching Functions and Graphs at Multiple Levels of Bloom's Revised Taxonomy." *PRIMUS* 20 (3): 204–216.
Greer, D., M. Rice, and D. Deshler. 2014. "Applying Principles of Text Complexity to Online Learning Environments." *Perspectives on Language and Literacy* 40 (1): 1–9.
Hadjianastasis, M. 2016. "Learning Outcomes in Higher Education: Assumptions, Positions and the Views of Early-Career Staff in the UK System." *Studies in Higher Education*. Accessed 17 June 2016. doi:10.1080/03075079.2014.966668.
Hall, S. L., F. Scott, and M. Borsz. 2008. "A Constructivist Case Study Examining the Leadership Development of Undergraduate Students in Campus Recreational Sports." *Journal of College Student Development* 49 (2): 125–140.
Hart Research Associates. 2016. "Trends in Learning Outcomes Assessment: Key Findings from a Survey among Administrators at AAC&U Member Institutions." Accessed 20 June 2016. https://www.aacu.org/sites/default/files/files/LEAP/2015_Survey_Report3.pdf.
Hassan, O. A. B. 2011. "Learning Theories and Assessment Methodologies – an Engineering Educational Perspective." *European Journal of Engineering Education* 36 (4): 327–339.
Henrichsen, L., and M. Tanner. 2011. "Creating Learning Outcomes for a TESOL Teacher Preparation Program." *TESOL Journal* 2 (4): 394–422.
Hertzog, P., and A. J. Swart. 2015. "Freshman Engineering Students Prefer Time-on-task in a Solar Energy Course, Rather Than Time-in-class!" Paper presented at the 19th International Conference on Engineering Education Zagreb, Zadar, Croatia.
Kelly, T. L. 1927. *Interpretations of Educational Measures*. Yonkers, NY: Wold Book.
Kennedy, D. 2007. "Writing and Using Learning Outcomes: A Practical Guide, Quality Promotion Unit, UCC." Accessed 13 June 2016. http://lo-hei.net/wp-content/uploads/2013/10/A-Learning-Outcomes-Book-D-Kennedy.pdf.
Kennedy, D., A. Hyland, and N. Ryan. 2006. "Writing and Using Learning Outcomes: A Practical Guide." Accessed 22 June 2016. http://www.tcd.ie/teaching-learning/academicdevelopment/assets/pdf/Kennedy_Writing_and_Using_Learning_Outcomes.pdf.
Khoza, S. B. 2001. "The Outcomes of Students Studying a Computer Literacy Course at Unischool." Med dissertation, University of Durban-Westville.
Khoza, S. B. 2013. "Learning Outcomes as Understood by 'Publishing Research' Facilitators at a South African University." *Mevlana International Journal of Education (MIJE)* 3 (2): 1–11.
Lapan, D. S., T. M. Quartaroli, and J. F. Riemer. 2012. "Introduction to Qualitative Research." In *Qualitative Research: An introduction to Methods and Designs*, edited by D. S. Lapan, T. M. Quartaroli, and J. F. Riemer, 3–18. San Francisco: Jossey-Bass.
Larkin, H., and B. Richardson. 2013. "Creating High Challenge/High Support Academic Environments Through Constructive Alignment: Student Outcomes." *Teaching in Higher Education* 18 (2): 192–204.
Luwes, N., and A. J. Swart. 2015. "Student Perspectives of Practical Work done in a Laboratory – a Case Study from Logic Design III." Paper presented at the International conference of engineering education, Zagreb, Croatia, July 20–24.
Melton, R. 2012. *Objectives, Competences and Learning Outcomes: Developing Instructional Materials in Open and Distance Learning*. London: Routledge.
Mogalakwe, M. 2006. "The Use of Documentary Research Methods in Social Research ." *African Sociological Review* 10 (1): 221–230.
Moon, J. 2002. *The Module and Programme Development Handbook: A Practical Resource for Linking Levels, Learning Outcomes and Assessment*. London: Kogan Page.
Neuman, L. W. 2011. *Social Research Methods: Qualitative and Quantitative Approaches*. Boston: Pearson.
O'Brien, S., and D. Brancaleone. 2011. "Evaluating Learning Outcomes: In Search of Lost Knowledge." *Irish Educational Studies* 30 (1): 5–21.

Pablo Picasso. n.d. BrainyQuote.com. Accessed 16 June 2016. http://www.brainyquote.com/quotes/quotes/p/pablopicas107571.html.
Palmer, S. 2004. "Authenticity in Assessment: Reflecting Undergraduate Study and Professional Practice." *European Journal of Engineering Education* 29 (2): 193–202.
Punch, F. K. 2009. *Introduction to Research Methods in Education*. London: SAGE Publications Limited.
Rahim, H. L., and R. Chik. 2014. "Graduate Entrepreneurs Creation: A Case of UniversitiTechnologi MARA, Malaysia." *Australian Journal of Basic and Applied Sciences* 8 (23): 15–20.
SAQA (South African Qualifications Authority). 2012. "The South African Qualifications Authority Level Descriptors for the South African National Qualifications Framework." Accessed 15 May 2014. http://www.saqa.org.za/docs/misc/2012/level_descriptors.pdf.
Schultz, M., and M. J. Hatch. 1996. "Living with Multiple Paradigms: The Case of Paradigm Interplay in Organisational Culture Studies." *The Academy of Management Review* 21 (2): 529–557.
Suskie, L. 2004. *Assessing Student Learning: A Common Sense Guide*. Bolton: Anker Publishing Company.
Swart, A. J. 2010. "Evaluation of Final Examination Papers in Engineering: A Case Study Using Bloom's Taxonomy." *IEEE Transactions on Education* 53 (2): 257–264.
Swart, A. J. 2014. "Ensuring the Sustainability of an Engineering Curriculum – A Case Study from a Telecommunications Course." *International Journal of Sustainable Development* 7 (11): 47–56.
Swart, A. J., K. Lombard, and H. De Jager. 2010. "Exploring the Relationship Between Time Management Skills and the Academic Achievement of African Engineering Students – A Case Study." *European Journal of Engineering Education* 35 (1): 79–89.
UNISA (University of South Africa). 2016. "Assessment Policies and Procedures Manual 2016." Accessed 20 June 2016. http://w3.unisa.edu.au/policies/manual/2016/APPM_2016_full_version.pdf.
University of Toronto. 2008. "Developing Learning Outcomes: A Guide for University of Toronto Faculty." Accessed 13 June 2016. http://teaching.utoronto.ca/wp-content/uploads/2015/08/Developing-Learning-Outcomes-Guide-Aug-2014.pdf.
Welch, R. W., S. J. Ressler, and A. C. Estes. 2005. "A Model for Instructional Design." *ASCE Journal of Professional Issues in Engineering Education and Practice* 131 (3): 167–171.
Willems, J. 2016. "Professional Development of Academic Staff in the Use of Social Media for Teaching and Learning." In 3rd European conference on social M di R h media research, Normandie, Caen, France.