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Graduate Attributes in an Electrical Engineering Curriculum: A Case Study*

LAWRENCE MEDA[1] and ARTHUR JAMES SWART[2]
[1] Cape Peninsula University of Technology, PO Box 13881 Mowbray, Cape Town, 7705, South Africa.
[2] Central University of Technology, Free State, P. Bag X20539, Bloemfontein, 9300, South Africa. E-mail: medalawrence@gmail.com

Industry and accreditation bodies around the world require graduates to be able to demonstrate specific graduate attributes. Universities in this 21st century have responded to that call by embedding graduate attributes into their curricula. However, how can individual academics ensure that they are incorporating and assessing graduate attributes in their respective modules, which form part of the overall curriculum? This research question necessitates reflection as many academics are struggling to come to terms with what many of these graduate attributes really mean or entail. Moreover, a dearth of research publications exists on trying to define and explain these graduate attributes. The purpose of this article is to determine to what extent have the 10 graduate attributes, adopted by the Central University of Technology been embedded into the curriculum of the National Diploma in Electrical Engineering. A qualitative case study was used and data was collected using documentary review. All 36 study guides of the Electrical Engineering qualification were analysed. Results of this study show that 9 out of 10 graduate attributes are spread across the entire curriculum. The four most dominate graduate attributes were found to be Innovation and Problem Solving; Technical and Conceptual Competence; Numeracy, and Technological Literacy. Certain graduate attributes are clearly discerned in the learning outcomes while others are hidden in different teaching and learning activities. A key recommendation of this study is for academics to structure their learning outcomes in a way that addresses the incorporation and assessment of key graduate attributes required.

Keywords: graduate attributes; indicators; engineering; outcomes

1. Introduction

It is commonly accepted that graduate attributes were originally formulated in response to industry needs. They have been widely adopted in all fields of education and form a critical part of university curricula in the 21st century. [1] argue that graduate attributes have received considerable attention as universities seek to renew and articulate their purposes. A key reason for this is that employers require student graduates to have twofold competencies: technical knowledge and skills and generic graduate attributes [2]. Thus, apart from acquiring disciplinary expertise, students also need to have a different skillset known as graduate attributes [3, 2]. [4] state that in response to the needs of contemporary employers, universities have developed graduate attributes. Contemporary industries therefore require student graduates to go beyond the disciplinary expertise or technical knowledge, and possess some general attributes such as enhanced communication and intrapersonal skills. Although there is no single and universally accepted definition of graduate attributes, many universities define them as:

> The qualities, skills and understandings a university community agrees its students should develop during their time with the institution. These attributes include, but go beyond, the disciplinary expertise or technical knowledge that has traditionally formed the core of most university courses. These attributes include qualities that must prepare graduates as agents of social good in an unknown future [5].

[6, p. 263] describes graduate attributes as capabilities which 'are not a set of additional outcomes requiring an additional curriculum, but, rather they are outcomes that can be reasonably expected from the usual higher education experience'. Graduate attributes are acquired through the way students engage with the course's learning experiences [7], and are not taught separately from the course content. Some educators view graduate attributes simply as learning outcomes which students should be able to demonstrate by the time they reach graduation [8]. Although graduate attributes are reiterated emphatically in universities today, their integration and assessment into all curricula remains elusive.

A challenge that is currently faced by many engineering educators in South Africa is a lack of knowledge of what graduate attributes really entail and how they should be integrated and assessed in the curricula. This is a global concern as many educators are struggling with how to effectively embed and assess graduate attributes within their curricula [9, 10]. [11] contend that incorporation and assessment of graduate attributes is the most complex and challenging part which many educa-

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tors tend to evade. Similarly, [4] argued that many educators still find it difficult to comprehensively and systematically embed graduate attributes in their curricula. The situation has hampered many universities' efforts to integrate graduate attributes into the curricula, with many viewing it as fraught with difficulties [12].

The situation is worse in engineering, as [13] argue that graduate attributes is a term which frequently shivers engineering educators. Compounding this problem is the fact that there is dearth of scholarship on integration and assessment of graduate attributes in South African universities [14], as many institutions continue to incorporate graduate attributes into their strategic planning and curricula [3]. The research question therefore arises 'To what extent have academics at a University of Technology in South Africa embedded graduate attributes into their Electrical Engineering qualification?'

The purpose of this article is to determine to what extent have the 10 graduate attributes, adopted by the Central University of Technology (CUT), been embedded into the curriculum of the National Diploma in Electrical Engineering (hereafter referred to as ND). These 10 graduate attributes correlate well with the 12 graduate attributes adopted by the International Engineering Alliance (IEA) [15]. The article will firstly review the link between the graduate attributes adopted by CUT and those mandated by the IEA. The structure of the Electrical Engineering programme at CUT will then be reviewed, along with the research methodology. Results follow with discussions and succinct conclusions.

1.1 IEA and central university of technology graduate attributes

Engineering educators in South Africa must strive to incorporate graduate attributes into their curricula to satisfy the requirements of their universities and professional bodies, such as the Engineering Council of South Africa (ECSA). ECSA is a signatory to the Washington, Dublin and Sydney accords, and a member of the IEA that has adopted an outcomes-based framework for accreditation [16]. All signatories to the Washington accord are expected to incorporate the 12 IEA stipulated graduate attributes and assess them using an outcomes based approach [17]. These 12 graduate attributes may be linked to the 10 adopted by CUT as shown in Table 1, where revised definitions are shown.

Graduate attributes such as Innovation and Problem Solving, Technological Literacy, Numeracy, Sustainable Development, and Technical and Conceptual Competence, are common to many engineering courses [18]. Problem-solving skills are required across the board in education, often being incorporated into project or problem-based learning which is used extensively in Electrical Engineering [19]. According to [20, 21] Innovation and Problem Solving is a major meta-attribute for graduate engineers. Technological literacy has become a fundamental requirement in the modern age, with recommendations that institutions must place more emphasis on the effective use of their learning management systems to benefit their students, especially so in Electronic Engineering [22]. All engineers should be fluent in a range of mathematical techniques, that relates to Numeracy, as this is a major component in many engineering courses [23]. Sustainable Development must be at the core of higher engineering education and will require a global commitment at social and economic levels [24]. Technical Competency is often demonstrated by students attending practical workshops that are mandated in engineering courses, where they are trained to use different equipment and acquire practical hands-on experience [25].

Some CUT's graduate attributes such as Communication and Team work are generic in nature. [26] maintain that in engineering many deliverables or outcomes are readily achieved by means of teamwork and communication. This infers that these two CUT graduate attributes are inseparable and must feature often in various engineering courses. They are generic in the sense that they are likely to be incorporated in almost every engineering course as educators are expected to use a student centred teaching approach which requires students to work in groups and communicate effectively [7].

Entrepreneurship is an attribute that cuts across all disciplines. [27] contend that engineers in the 21st century should have entrepreneurial skills. Although graduates in various disciplines are expected to have entrepreneurial skills, Entrepreneurship is downplayed in engineering. This is mainly because academics claim they are not trained to teach it [28] and also a wide view that entrepreneurship is for business related courses [19].

Community Engagement is an attribute expected from all graduates in this 21st century. Engineering programmes are reviewed to incorporate definitive steps to educate students on engaging communities for sustainable development [29]. Citizenship and Global Leadership is an attribute that all engineering graduates ought to have because they are expected to function competently in different multicultural contexts around the globe [30]. All CUT graduate attributes are expected to be incorporated into the curriculum.

[16] suggests that graduate attributes can be embedded into curricula by developing learning outcomes with explicit indicators. These indicators are descriptors of what students must be able to

Table 1. Linking the graduate attributes prescribed by the IEA and CUT along with succinct definitions

IEA Graduate Attributes	CUT Graduate Attributes	Definitions of CUT Graduate Attributes
Engineering Knowledge	Numerate (N)	Graduates should be able to use basic mathematics, budgeting and financial management skills.
Problem Analysis	Innovation and problem solving (IPS)	Graduates should be innovative, think creatively and critically and apply a range of strategies to solve/find solutions for real world problems. They should demonstrate ability to apply theoretical knowledge that will lead to development of new ideas, methods, techniques, practices, products and services in a variety of contexts (technology, commerce, social system, economic development and policy development).
Design /development of solutions	Technical and conceptual competence (TCC)	Graduates should be able to demonstrate depth of specialised disciplinary knowledge and skills and be able to apply them in different contexts to solve problems by effectively using specific equipment or procedures.
Investigation	Innovation and problem solving (IPS)	Graduates should be innovative, think creatively and critically and apply a range of strategies to solve/find solutions for real world problems. They should demonstrate ability to apply theoretical knowledge that will lead to development of new ideas, methods, techniques, practices, products and services in a variety of contexts (technology, commerce, social system, economic development and policy development).
Modern Tool Usage	Technologically literate (TL)	Graduates should be able to use information and communication technologies effectively.
The Engineer and Society	Community engagement (CE)	Graduates should be socially engaged in their communities.
Environment and Sustainability	Sustainable development (SD)	Graduates should be environmentally sensitive and should recognise their roles as socially responsible citizens who care for the common good of others, their country and environment.
Ethics	Citizenship and global leadership (CGL)	Graduates should be able to make meaningful and positive contribution to society, be ethical and visionary leaders who can show leadership in different contexts.
Individual and Team work	Teamwork (T)	Graduates should be able to work independently and in teams, to manage their own learning, work and take responsibility for self while contributing to teams such as learning communities.
Communication	Communication (C)	Graduates should communicate proficiently, in oral, written, presentation, information searching and listening skills. They should be assertive and articulate, be able to negotiate responsibly and persuade others effectively.
Project Management and Finance	Citizenship and global leadership (CGL)	Graduates should be able to make meaningful and positive contribution to society, be ethical and visionary leaders who can show leadership in different contexts.
Lifelong learning	Entrepreneurship (E)	Graduates should be entrepreneurial, industrious and be able to recognise opportunities and turn them into ideas for enterprises. They should have business acumen and display basic business skills.

demonstrate for each attribute. In Engineering, educators are required to measure indicators, not graduate attributes [1]. Subsequently, embedding graduate attributes into an engineering curriculum requires educators to develop learning outcomes with specific and measurable indicators. Reviewing and analysing the learning outcomes of a curriculum, as stated in the different study guides, is therefore a good starting point in determining to which extent have the various graduate attributes been embedded into an Electrical Engineering curriculum.

1.2 The electrical engineering curriculum

The ND 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 [31]. Students may choose from 36 modules within this qualification (each with its own credit value) to accumulate a minimum of 240 credits. However, 9 modules are compulsory for all specializations and are shown in Table 2, where the computer and communication skills modules only have 6 credits awarded to them. Students are further required to complete at least 5 exit level modules (e.g. Design

Table 2. Compulsory modules in the Electrical Engineering qualification

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 the learners to electrical engineering concepts and techniques.
Electrical Engineering II	12	Let's 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 devices.
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.

Projects III (structure described by [32]) Mathematics III, Power Electronics III, Logic Design III and Radio Engineering III (structure described by [19]). 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 [33]. These specializations would require students to complete a specific sequence of approximately 20 modules out of the available 36. The Electrical Engineering qualification include both theoretical and practical instruction where students can demonstrate vital graduate attributes within a laboratory environment [34].

1.3 Conceptualisation of learning outcomes and teaching and learning activities

Learning outcomes and teaching and learning activities are at the centre of higher education. They complement each other in the sense that learning outcomes influence the selection and organisation of teaching and learning activities [35]. Despite widespread information about learning outcomes, limited evidence exists concerning academics' use of them in higher education [36]. [37, 38] argue that there is an on-going debate among scholars concerning the use of learning outcomes in higher education. This, at times, results in some educators not developing effective learning outcomes which promote student learning [39].

Learning outcomes can be conceptualised as formal statements of what students are expected to learn in a course [40]. Simply stated, learning outcomes describe what educators want students to know and to be able to do at the end of the course [39]. By providing specific statements of students' achievements on completion of a particular period of learning (e.g. at the end of a module, course or programme) enable qualifications to be more easily described [36]. In this study, graduate attributes are expected to be incorporated into the learning outcomes so that students will know what competences they are expected to know by the end of the course. When embedding graduate attributes in learning outcomes, it is important for educators to use indicators or descriptors of competences which students must demonstrate [7]. That will make it easy to identify the different graduate attributes that need to be found across any given curriculum in higher education.

Teaching and learning activities are the actual actions which take place inside or outside the classroom environment. These activities are influenced by the learning outcomes, which in turn inform assessment practices [41]. Students get to learn graduate attributes through teaching and learning activities which they perform [42]. For example, if they are required by an educator to work on a project in groups, then they will have to acquire attributes such as team work and communication to successfully complete the project. The methodology of the study is discussed next.

2. Methodology

The 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. A qualitative approach was also chosen as it enabled researchers to generate rich textual data from reviewed documents. An interpretive position was preferred as it is compatible with a qualitative approach. [43] argue that all qualitative research has an interpretive perspective which focuses on understanding and interpreting meaning of a phenomenon.

The study focused on the case of the ND offered by the Department of Electrical, Electronic and Computer Engineering at CUT. A case study is usually used to increase the understanding of certain complex phenomena [44]. In this research, the phenomenon is to determine the extent to which the 10 CUT graduate attributes have been embedded into the Electrical Engineering curriculum. According to [45] 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 [46].

Data was collected using documentary review. Documentary review refers to a systematic process of analysing written texts that contain information about the phenomenon under study [47]. This method is efficient and more cost effective than social surveys, in-depth interviews or participant observations [48]. Documents reviewed in this research were all 36 study guides that were compiled for the Electrical Engineering qualification. The study guides were purposely chosen in order to provide a complete picture of the current status of graduate attributes within this curriculum. It must be emphasised that these study guides, as a whole, must incorporate all of the graduate attributes stipulated by the institution and the IEA. Outcomes as well as teaching and learning activities were analysed in order to determine which of the 10 graduate attributes adopted by CUT are being addressed. Data was recorded in a graduate attribute matrix that was developed and used as an analytical framework. This matrix is presented in the following section.

3. Results

Findings of this study have been presented in the form of a matrix of graduate attributes, as shown in Table 3. Graduate attributes explicitly stated in the learning outcome are indicated by means of a (√) while graduate attribute derived from the teaching and learning activities are indicated by a (•). The acronyms listed in top reflect the 10 graduate attributes of CUT as listed in Table 1 (e.g. T = Teamwork, C = Communication, N = Numeracy and E = Entrepreneurship).

Table 3 reveals that only nine graduate attributes were explicitly found in the 36 study guides of the Electrical Engineering qualification, being discerned from the learning outcomes and teaching and learning activities. Only one graduate attribute, Citizenship and Global Leadership (CGL), was not explicitly stated or referred to in the study guides. The definitions of the acronyms are listed in Table 1, column 2 (e.g. N = Numerate).

The top four prominent graduate attributes in the 36 study guides are Innovation and Problem Solving (IPS featuring 34 times), Technical and Con-

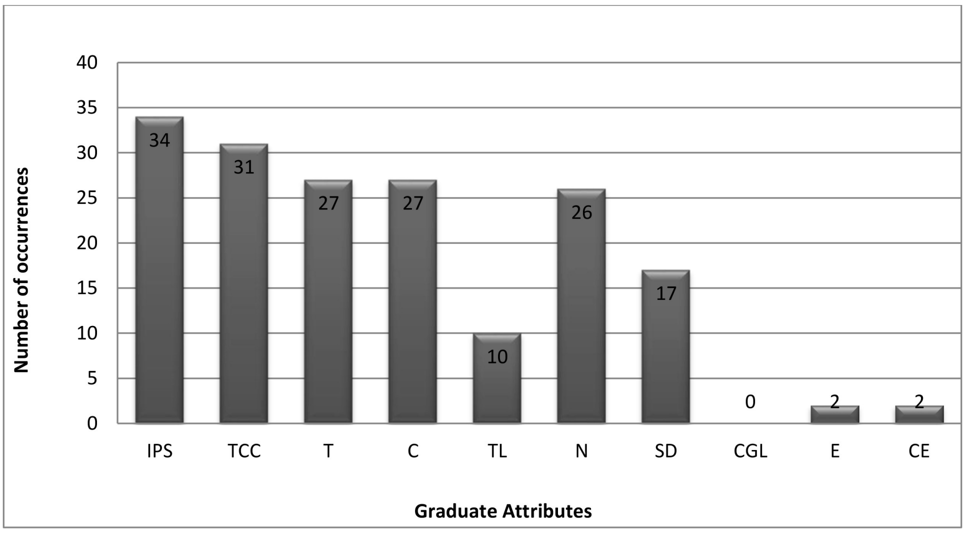

Fig. 1. Histogram showing the total number of occurrences of Graduate Attributes in an Electrical Engineering qualification.

Table 3. Matrix of Graduate Attributes

Num.	Module	IPS	TCC	T	C	TL	N	SD	CGL	E	CE
1	Applied Strength of Materials III	√	√	•	•		√	•			
2	Control Systems III	√	√	•	•		√	•			
3	Digital Systems I	√	√	•	•		√	•			
4	Digital Systems II	√	√	•	•		√	•			
5	Digital Systems III	√	√	•	•		√	•			
6	Electrical Distribution III	√	√	•	•		√	•			
7	Electrical Engineering I	√	√	•	•		√	•			
8	Electrical Engineering II	√	√	•	•		√	•			
9	Electrical Engineering III	√	√	•	•		√	•			
10	Electronic Applications III	√	√	•	•		√	•			
11	Electronic Communication II	√	√	•	•		√	•			
12	Electrical Machines II	√	√	•	•		√	•			
13	Electrical Machines III	√	√	•	•		√	•			
14	Electrical Protection III	√		•	•	•	√	•			
15	Logic Design III	√	√	•	•	√					
16	Mechanics I	√	√	•	•	•	√				
17	Power Electronics III	√		•	•	√		•			
18	Projects I	√	√	•	•	√		•			•
19	Projects II	√	√	•	√	√				√	√
20	Software Design II	√	√			√		√			
21	Design Project III	√	√	•	√	•				√	
22	Communication Skills I	√	√	√	√	√					
23	Computer Skills 1	√	√	√	√	√					
24	Electronics I	√	√	•	•		√				
25	Electronics II	•	√	•	•		√				
26	Electronics III	√	√								
27	Industrial Electronics II	√		•	•		√				
28	Mathematics I	•	√				√				
29	Mathematics II	•	√				√				
30	Mathematics III	•	√				√				
31	Mechanical Technology I	√	√				√				
32	Mechanical Technology II	√	√				√				
33	Mechanical Technology III		√				√				
34	Radio Engineering III		√								
35	Strength of Materials II	√		•	•		√				
36	Strength of Materials III	√		•	•		√				
37	Work Integrated Learning I										
38	Work Integrated Learning II										

IPS = Innovation and problem solving; TCC = Technical and conceptual competence; T = Teamwork; C = Communication; TL = Technologically literate; N = Numerate; SD = Sustainable Development; CGL = Citizenship and global leadership; E = Entrepreneurship; CE = Community Engagement.

ceptual Competence (TCC featuring 31 times), Teamwork (T featuring 27 times) and Communication (C featuring 27 times). A histogram of the total number of occurrences of the graduate attributes is shown in Fig. 1.

Technological Literacy (TL featuring 10 times), Numeracy (N featuring 26 times) and Sustainable Development (SD featuring 17 times) form the middle three graduate attributes of the programme. The bottom three graduate attributes are Citizenship and Global Leadership (CGL featuring 0 times), Entrepreneurship (E featuring 2 times) and Community Engagement (CE featuring 2 times). These latter two attributes were found to exist in modules pertaining to project design (i.e. Projects I and II and Design Projects III). In Projects II, it is articulated in one of the outcomes that students should be able to write a proposal and design a detailed poster for marketing purposes. Proposal writing and poster design are critical components used for marketing purposes which subsequently address a graduate attribute of Entrepreneurship. Similarly, in Design Project III, a learning activity in line with the outcome of entrepreneurship states 'Students are expected to design, construct, evaluate and compile relevant documentation of an integrated project, with an industry-orientated approach, which will promote an entrepreneurial attitude in respect of technological innovation and analysis.'

The graduate attribute of Technological Literacy was mainly incorporated in outcomes where educators required students to design software for electronic applications. It was also embedded in teaching and learning activities which required students to use the university's learning management system, called eThuto.

Team work, Communication and Sustainable Development were more readily discerned in the teaching and learning activities as compared to the listed outcomes. They were not mainly incorporated using indicators, but were rather infused into activities which educators specified for their students. Educators often combined team work and communication. The two are very compatible in the sense that when students are asked to work as a team, communication will subsequently be addressed. The graduate attribute (Sustainable Development) was only mentioned as a learning outcome in Software Design II, where students were required to create sustainable and interactive user interfaces.

4. Discussion

The current graduate attributes, which exist in the Electrical Engineering qualification at CUT, are not completely aligned with the requirements of the Washington accord which states that outcomes must be used as a framework for assessing graduate attributes [17]. Some graduate attributes at CUT are stated as teaching and learning activities, and not as learning outcomes. That presents a problem in engineering as educators are expected to develop specific indicators in order to make it easy to measure graduate attributes [1]. As long as graduate attributes are not explicitly stated in learning outcomes, their reliable and valid assessment remains problematic. Finelli et al. [49] suggested the development of a taxonomy of keywords to be used in engineering with the intention of ensuring that academics cover what students need to learn in the outcomes. This is consistent with Biggs' constructive alignment which reiterates that the stated outcomes inform teaching and learning and assessment strategies [35].

Incorporation of graduate attributes is still a big challenge in engineering education, as many engineering educators find it difficult to incorporate them into their curriculum [13]. In some cases, engineering educators find it hard to incorporate graduate attributes into the curriculum because of misconceptions that they have. Some educators think that graduate attributes require a unique set of outcomes which are different from outcomes of a module [6]. This is not the case, as graduate attributes are attainable together with learning outcomes and experiences planned for students in a particular module.

In the engineering context, graduate attributes such as Innovation and Problem Solving, Technical and Conceptual Competence and Numeracy are easy to incorporate into the curriculum due to their biasness to the profession [6]. They are viewed as hard skills which engineering students must be able to demonstrate, and featured in some 26 or more modules within the Electrical Engineering qualification at CUT.

On the other hand, graduate attributes such as Teamwork, Communication, Entrepreneurship and Citizenship and Global Leadership are soft skills [26]. However, engineering graduates are expected to possess both hard and soft skills [10]. A student centred teaching approach requires students to work in groups and communicate effectively [7]. The results of this study showed that both Teamwork and Communication have been found in 27 modules of the Electrical Engineering qualification. However, they have only been explicitly written in learning outcomes for four modules. Team work is crucial as students learn more from good team experiences than they do from bad experiences [50]. Employers expect engineering graduates to function increasingly in teams and participate effectively in projects [51].

5. Conclusion

The purpose of this article was to determine the extent to which the 10 graduate attributes, adopted by CUT, have been embedded into the Electrical Engineering curriculum. Although nine graduate attributes were embedded across the curriculum, one was omitted (Citizenship and Global Leadership). Graduate attributes were incorporated in both learning outcomes and teaching and learning activities. 104 learning outcomes specifically referred to some of the graduate attributes while 72 teaching and learning activities were found to incorporate other graduate attributes (see Table 3). Incorporating all graduate attributes in learning outcomes and activities across the curriculum has therefore not optimally been achieved, as some academics may not be fully aware of what each attribute entails or how to assess it.

Aligning all the graduate attributes to the learning outcomes, rather than to the teaching activities, have a three-fold advantage: i) students unambiguously know what they are expected to do in order to develop specific graduate attributes; ii) it simplifies the process of developing assessment measures, and iii) 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. This of course implies that all the learning outcomes must be clear, observable and measurable that may assist all students in Higher Education to eventually accomplish that which they could not originally do.

In order to ensure that all graduate attributes are embedded in the learning outcomes of modules within a curriculum, it is recommended that a programme mapping exercise be completed for each curriculum, as was completed in this study for the Electrical Engineering qualification at CUT. This programme mapping exercise will enable educators to discern if ALL the required graduate attributes have been addressed in the right modules. It must be re-emphasised, that not ALL graduate attributes must feature in one module, but rather in one curriculum. This will also help students to identify the specific graduate attributes which they need to master in order to go beyond disciplinary expertise and technical knowledge.

This study further recommends staff capacity development workshops on incorporation and assessment of graduate attributes in the curriculum. This will enable educators to become more aware of what graduate attributes are and how to embed them into the curriculum. Creating awareness among academics about graduate attributes and undertaking a programme mapping exercise may alleviate the difficulty that academics experience in embedding graduate attributes into a curriculum. This has the potential to further meet industry needs, which include the provision of graduates with the right attributes to contribute significantly to the socio-economic development of communities and countries.

References

1. C. Hughes and S. Barrie, Influences on the assessment of graduate attributes in higher education, *Assessment & Evaluation in Higher Education*, **35**(3), 2010, pp. 325–334.
2. B. Leask, *Internationalizing the Curriculum*, Routledge, Oxon: 2015.
3. J. Greenbaum and G. Rycroft, The development of graduate attributes: The Book of the Year project. *South African Journal of Higher Education*, **28**(1), 2014, pp. 91–109.
4. M. Osmani, V. Weerakkody, N. M. Hindi, R. Al-Esmail, T. Eldabi, K. Kapoor and Z. Irani, Identifying the trends and impact of graduate attributes on employability: a literature review, *Tertiary Education and Management*, **21**(4), 2015, pp. 367–379.
5. J. Bowden, G. Hart, B. King, K. Trigwell and O. Watts, Generic capabilities of ATN University graduates 2000, www.clt.uts.edu.au/ATN.grad.cap.project.index.html/, [Accessed 11 December 2011].
6. S. Barrie, A research-based approach to generic graduate attributes policy, *Higher Education Research and Development*, **23**(3), 2004, pp. 262–275.
7. S. C. Barrie, A conceptual framework for the teaching and learning of generic graduate attributes, *Studies in Higher Education*, **32**(4), 2007, pp. 439–458.
8. S. M. Easa, Framework and guidelines for graduate attribute assessment in engineering education. *Canadian Journal of Civil Engineering*, **40**, 2013, pp. 547–556.
9. S. Sin and N. McGuigan Fit for Purpose: A Framework for Developing and Assessing Complex Graduate Attributes in a Changing Higher Education Environment, *Accounting Education: an International Journal*, **22**(6), 2013, pp. 522–543.
10. R. Moalosi, M. T. Oladiran and J. Uziak, Students' perspective on the attainment of graduate attributes through a design project, *Global Journal of Engineering Education*, **14**(1), 2012, pp. 40–46.
11. D. Ipperciel and S. Elatia, Assessing Graduate Attributes: Building a Criteria-Based Competency Model, *International Journal of Higher Education*, **3**(3), 2014, pp. 27–38.
12. K. Chanock, Developing criteria to assess graduate attributes in students' work for their disciplines. *Journal of Learning Development in Higher Education*, **6**, 2013, pp. 1–16.
13. L. D. Nghiem, T. Goldfinch and M. Bell, *Embedding Graduate Attribute Development into the Engineering Curriculum: Less is More?* Proceedings of the 2010 AaeE Conference, Sydney, 2010.
14. F. N. Mashiyi, Embedding Graduate Attributes into the Foundation Programme: Reflections on Process and Product, *South African Journal of Higher Education*, **27**(1), 2015, pp. 181–197.
15. A. J. Swart and P. E. Hertzog, Contrasting three different academic's assessments of a compulsory capstone module in power engineering indicates reliability! *24th South African Universities Power Engineering Conference*, SAUPEC 2016, 26–28 January 2016, Vaal University of Technology, Three Rivers Lodge, 2016.
16. Engineering Council of South Africa [ECSA] (2015). *International Recognition*, https://www.ecsa.co.za [Accessed 07 September 2015].
17. International Engineering Alliance [IEA], (2013). *Graduate Attributes and Professional Competencies*. http://www.ieagreements.org/IEA-Grad-Attr-Prof-Competencies.pdf [Accessed 08 February 2016].
18. H. R. Maier and T. S. C. Rowan, Increasing student

engagement with graduate attributes, *Australasian Journal of Engineering Education*, **13**(1), 2007, pp. 21–29.
19. A. J. Swart, Using problem-based learning to stimulate entrepreneurial awareness among senior African undergraduate students, *EJMSTE, Eurasia Journal of Mathematics, Science and Technology Education*, **10**, 2014, pp. 125–134.
20. D. F. Radcliffe, Innovation as a Meta-Attribute for Graduate Engineers, *International Journal of Engineering Education*, **21**(2), 2005, pp. 194–199.
21. W. van Niekerk and E. Mentz, Cooperative pair problem solving: a strategy for problem solving tutorials in the engineering sciences, *International Journal of Engineering Education*, **31**(6), 2015, pp. 1516–1525.
22. A. J. Swart, Student usage of a learning management system at an open distance learning institute—A case study in electrical engineering, *International Journal of Electrical Engineering Education*, **52**(4), 2015, pp. 142–154.
23. C. Fernández, M. A. Vicente and L. M. Jiménez, Virtual laboratories for control education: a combined methodology, *International Journal of Engineering Education*, **21**(6), 2005, pp. 1059–1067.
24. J. Quadrado, *Engineering for Sustainable Development: Graduate and Undergraduate Education*, Doctoral dissertation, Instituto Superior de Engenharia de Lisboa Lisbon, Portugal, 2013.
25. A. J. Swart, Distance Learning Engineering Students Languish Under Project-Based Learning, But Thrive in Case Studies and Practical Workshops, *IEEE Transactions on Education*, **59**(2), 2016, pp. 98–104.
26. M. T. Oladiran, J. Uziak, M. Eisenberg and C. Scheffer, Global engineering teams—a programme promoting teamwork in engineering design and manufacturing, *European Journal of Engineering Education*, **36**(2), 2011, pp. 173–186.
27. G. B. Da Silva, H. G. Costa and M. D. De Barros, Entrepreneurship in Engineering Education: A Literature Review, *International Journal of Engineering Education*, **31**(6) 2015, pp. 1701–1710.
28. R. Radharamanan and J. Juang, Innovation and entrepreneurship in engineering education at MUSE, *Journal of the Chinese Institute of Engineers*, **35**(1), 2012, pp. 25–36.
29. D. J. Gilbert, M. L. Held, J. L. Ellzey, W. T. Bailey and L. B. Young, Teaching 'community engagement' in engineering education for international development: Integration of an interdisciplinary social work curriculum, *European Journal of Engineering Education*, **40**(3), 2015, pp. 256–266.
30. T. D. Taverney and J. D. Rendleman, Engineering Global Leadership, *Astropolitics*, **9**(2–3), 2011, pp. 119–139.
31. Central University of Technology [CUT] 2016.*University Calendar 2016.* www.cut.ac.za [Accessed 9 May 2016].
32. A. J. Swart, K. Lombard and H. De Jager. 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), 2010, pp. 79–89.
33. P. Hertzog and A. Swart, Freshman engineering students prefer time-on-task in a Solar Energy course, rather than time-in-class!, *in ICEE 2015 19th International Conference on Engineering Education Zagreb*, Zadar (Croatia), 2015.
34. N. Luwes and A. J. Swart, Student Perspectives of Practical Work done in a Laboratory—a Case Study from Logic Design III, *International conference of engineering education*, ICEE 2015, July 20–24, 2015 Zagreb, Croatia.
35. J. Biggs, *Teaching for quality learning at university*, Open University Press: Buckingham
36. K. Dobbins, S. Brooks, J. J. A. Scott, M. Rawlinson and R. I. Norman, Understanding and enacting learning outcomes: the academic's perspective, *Studies in Higher Education*, **41**(7), 2016, pp. 1217–1235.
37. C. E. Rees, The Problem with Outcome-based Curricula in Medical Education: Insights from Educational Theory, *Medical Education*, **38**(6), 2004, pp. 593–598.
38. D. Buss, Secret Destinations, *Innovations in Education and Teaching International*, **45**(3), 2014, pp. 303–308
39. S. Brooks, K. Dobbins, J. J. A. Scott, M. Rawlinson and R. I. Norman, Learning about learning outcomes: the student perspective, *Teaching in Higher Education*, **19**(6), 2014, pp. 721–733.
40. Texas University, (n.d). *Writing and Assessing Course-Level Student Learning Outcomes*. https://www.depts.ttu.edu/opa/resources/docs/Writing_Learning_Outcomes_Handbook3.pdf [Accessed on 06 May 2016].
41. J. Biggs, What the student does: teaching for enhanced learning, *Higher Education Research & Development*, **31**(1), 2012, pp. 39–55.
42. S. C. Barrie, *Conceptions of Generic Graduate Attributes*, PhD Thesis. 2003.
43. D. S. Lapan, T. M. Quartaroli and J. F. Riemer, Introduction to Qualitative Research. In S D. Lapan, T. M. Quartaroli and F. J. Riemer (Eds.), *Qualitative Research: An introduction to Methods and Designs*, San Francisco: Jossey-Bass, 2012, pp. 3–18.
44. H. L. Rahim and R. Chik, Graduate Entrepreneurs Creation: A Case of Universiti Technologi MARA, Malaysia, *Australian Journal of Basic and Applied Sciences*, **8**(23), 2014, pp. 15– 20.
45. F. K. Punch, *Introduction to Research Methods in Education*, Sage Publications Ltd, London, 2009.
46. S. L. Hall, F. Scottand and M. Borsz, A Constructivist Case Study Examining the Leadership Development of Undergraduate Students in Campus Recreational Sports, *Journal of College Student Development*, **49**(2), 2008, pp. 125–140.
47. K. Bailey, *Methods of Social Research*, The Free Press, New York, 1994.
48. M. Mogalakwe, The Use of Documentary Research Methods in Social Research, *African Sociological Review*, **10**(1), 2006, pp. 221–230.
49. C. J. Finelli, M. Borrego and G. Rasoulifar, Development of a Taxonomy of Keywords for Engineering Education Research, *European Journal of Engineering Education*, **41**(3), 2016, pp. 2–18.
50. M. R. Perello-Marin, P. L. Vidal-Carreras and J. A. Marin-Garcia, What Do Undergraduates Perceive About Teamwork? *International Journal of Engineering Education*, **32**(3), 2016, pp. 1171–1181.
51. K. A. Smith, *Strategies for developing engineering student's teamwork and project management* http://faculty.kfupm.edu.sa/COE/elrabaa/rich%20text/general%20presentations/20565.pdf [Accessed 18 December 2008].

Lawrence Meda holds a PhD in Education from the University of KwaZulu Natal in South Africa. He is currently working at Cape Peninsula University of Technology as a Teaching and Learning Coordinator. His research interests are in Curriculum Studies and Inclusive Education.

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 an Associate Professor at the Central University of Technology in South Africa, where he is the Principal Research Leader for a research group in Engineering Education. His research interests include metrology and using educational technology to promote student engagement.