ENSURING THE SUSTAINABILITY OF AN ENGINEERING CURRICULUM – A CASE STUDY FROM A TELECOMMUNICATIONS COURSE

Arthur James Swart
Faculty of Engineering and IT, Central University of Technology, Willows, Bloemfontein, South Africa
Corresponding author: aswart@cut.ac.za

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Abstract: Sustainability has been extensively promoted across all spheres of life, including engineering, business management and education. The purpose of this paper is to highlight how an engineering curriculum can be made sustainable in order to benefit both academics and students alike. It places particular emphasis on reflecting on and revising vague learning outcomes, which are not conducive to a sustainable curriculum. A possible definition for a sustainable curriculum is substantiated which is based on its learning outcomes that need to be clear, concise, measurable, manageable, reasonable and sustainable, being interpreted in the same way between relevant registered students from different cohorts and between academics within the same department. Feedback was obtained via a focus group interview of post-graduate engineering students in a telecommunications course who indicated that the revised learning outcomes where easier to understand, enabling them to know what was exactly expected from them.

Keywords: Clarity, Conciseness, Learning outcomes, Manageability, Measurability

INTRODUCTION

"I'm not a left-wing person. I'm just a person interested in the sustainability of my country" [1]. These words by a well know actor, Robert Redford, highlights the ever-increasing awareness of ensuring sustainability, whether it involves energy generation, economic systems, business ventures, social endeavors, environmental affairs or higher education. Indeed, sustainability involves the multiple objectives of social, economic, resources and environmental sustainability with some of them regularly conflicting [2]. A large and growing body of research examining sustainability in higher education has emerged in the past decade [3] including research into ensuring sustainable curriculums.

The notion of a sustainable curriculum may be interpreted in different ways [4]. Some academics define a sustainable curriculum in terms of being able to develop the professional competencies of engineering graduates [5], while others advocate that a sustainable curriculum should integrate the learning and professional needs of the whole student body [6]. These graduate attributes and learning needs must be well articulated if both academics and students are to know what is expected from them! Rickman [7] states that a sustainable curriculum should have a holistic framework while Watson et al. [8] considers the point of view of a student in that a sustainable curriculum should exert power in terms of securing employment, encouraging further study and obtaining citizenship. Added to this is the need for a sustainable curriculum to engender a student culture of lifelong learning [9].

A desire exists to develop sustainable curriculum models which includes the design and development of creative curriculum [10]. This creative curriculum needs to keep pace with the technological advances in modern society, helping students to easily integrate themselves into an industrial world which keeps changing rapidly and un-expectantly. In order to fulfill the societal demands and to keep pace with the rapid advancement of technology in engineering, sustainable curriculum is currently being advocated in many educational disciplines and professions [11]. Relevant and sustainable curriculum reform would require research on effective local innovative practices of academics in adapting curricula and materials to the concrete challenges at the local level, and disseminating these practices rather than simply emulating practices [12]. Reflecting on current engineering curriculums in order to adapt them to help students solve real world problems is therefore a necessity! This is especially so as many student graduates cannot reason clearly or perform competently in analyzing complex, nontechnical problems, even though Faculties of Education rank critical thinking as the primary goal of a college education [13]. While educational institutions face issues of creating flexible and sustainable curriculums [14], their faculties need to engender a collective responsibility of creating systemic and sustainable curriculums [15].

The purpose of this paper is to highlight how an engineering curriculum can be made sustainable in order to benefit both academics and students alike. It places particular emphasis on reflecting on and revising vague learning outcomes, which are not conducive to a sustainable curriculum, expressing them in explicit, reasonable and measurable terms. A case study is used from a telecommunications course offered at a University of Technology where student feedback on the revised learning outcomes was obtained by means of a focus group interview. Quantitative results were primarily obtained and presented in a number of figures and tables with succinct conclusions being drawn. The curriculum design process will firstly be considered in order to establish that explicit, reasonable and measurable learning outcomes play a significant role in ensuring a sustainable curriculum.

CURRICULUM DESIGN PROCESSES AND ANOTHER POSSIBLE DEFINITION FOR A SUSTAINABLE CURRICULUM

A number of curriculum design processes exist, which includes: (a) Backward design (see Fig. 1) [16, 17] (b) Forward design (see Fig. 2) [16] (c) Student-centered design (see Fig. 3) [18]

The backward design incorporates the thoughtful consideration of instructional goals, the conceptualization of assessments to evaluate the achievement of those goals, and the instruction needed to meet those goals [17]. The backward design starts with the learning outcomes which stipulate what students should be able to do, demonstrate or achieve during the course or at the end of the course. Developing these learning outcomes is usually a collective effort involving a number of stakeholders, including official accreditation bodies (such as the Engineering Council of South Africa (ECSA)), industry partners (such as Telkom SA), academics within a relevant department and curriculum design specialists. Assessment strategies are then selected to suit these learning outcomes so that students can successfully demonstrate if they have achieved them. Pedagogies suited to the learning outcomes and assessment strategies are next considered and selected on the basis of providing the correct learning environment in which students can succeed. A syllabus based on the learning outcomes is then developed and relevant content is sought to support the syllabus and learning outcomes. It is important to note that the learning outcomes form the basis for each of the subsequent backward steps and must therefore be developed in a detailed, thorough and holistic manner.

The forward design starts with the syllabus. Again, consultation among key stakeholders is the first step in determining the core syllabus of a curriculum. Content, in terms of a prescribed book, e-book or journal articles is then selected to cover the topics listed in the syllabus. Pedagogical methods should then be chosen with both the content and student in mind which will eventually lead to the assessment strategies required to assess the content. Only then are the explicit, reasonable and measurable learning outcomes formulated.

The student-centered design of curriculum focuses on the needs of the students in formulating the objectives, assessments and instruction. A continuous feedback cycle exists between [18]: (a) planning (identifying course content and defining measurable learning objectives for it); (b) instruction (selecting and implementing the methods that will be used to deliver the specified content and facilitate student achievement of the objectives); and (c) assessment (selecting and implementing the methods that will be used to determine whether and how well the objectives have been achieved and interpreting the results) that leads to continuous improvement.

It should be noted that, in an ideal world, the writing of learning outcomes should be the first stage in the creation of any unit of teaching [19]. Using the backward design for sustainable curriculums in engineering has the advantage of including real life problems upfront, as the initial focus of students is turned towards solving an engineering problem which is a key graduate attribute of any engineering student. It has long been advocated that theory and practice must be integrated into any engineering curriculum [20, 21] and that engineering students need to be assisted in how to apply theory in different practical contexts. Stating the practical context or problem upfront and having students locate and apply relevant theory to solve the problem is a prime example of problem-based learning, which usually starts with a learning outcome [22]. A substantial body of literature further indicates that problem-based learning has important advantages over more traditional pedagogies in producing sustainable learning outcomes [23]. Problem-based learning has helped students to conceptualize different engineering fundamentals [24, 25] in order to develop holistically acceptable solutions to engineering problems [26] and has been widely used in many engineering curriculums. Ernest Boyer [27] developed a model of scholarship in which he advises academic leaders to adopt new ways of scholarship, looking for new connections to their theory, while at the same time building bridges between theory and practice. Equally important is developing the ability to effectively communicate these new connections and bridges to aspiring students by means of effective learning outcomes.

Figure 1: Backward design for a curriculum

Figure 2: Forward design for a curriculum

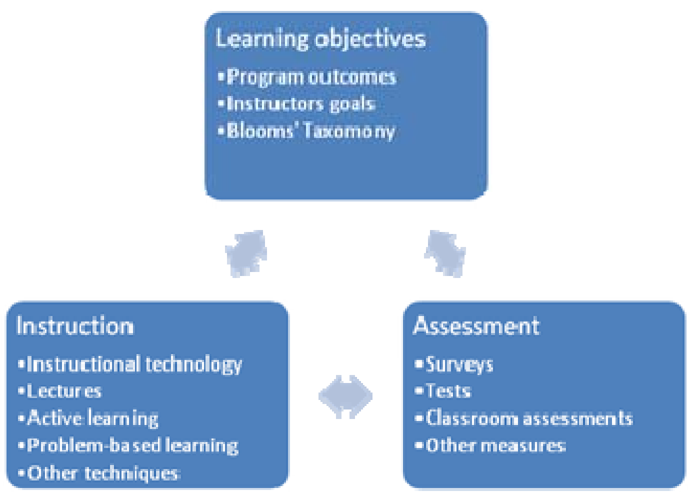

Figure 3: Student-centered design for a curriculum

Using learning outcomes then, as the starting point for designing a sustainable curriculum, requires a number of important principles, namely: (a) Clarity; (b) Conciseness; (c) Measurability; (d) Manageability; (e) Reasonability; and (f) Sustainable.

Learning outcomes should not be too broad, but must be concise and measurable, being kept to a manageable number and being reasonable [28], being communicated to the students at the start of the course [29]. It has been reported that there is a positive correlation between a high number of student dropouts and a low number of learning outcomes [30]. On the other hand, some students may become intimidated by the fact that many learning outcomes exist within a given curriculum [19]. Too many learning outcomes may also be prescribed for too short a period of time or too few learning outcomes may be prescribed for a too lengthy period of time [31]. This really necessitates a balance between the number of concise learning outcomes (i.e. outcomes which are limited in the number of words used and that get to the point) and the notional hours that a student is required to spend in a specific module, which is usually dictated by the number of credits awarded that module in South Africa.

Learning outcomes also need to be measurable and well-defined so that all teaching and learning activities can support student achievement of the learning outcomes [32]. The alignment aspect of constructive alignment refers to establishing a teaching environment where the teaching activities support and lead to the achievement of the desired learning outcomes as evidenced by students' engagement with the assessment tasks [33]. Learning outcomes should furthermore be clear statements of what the learners will be able to do [34]. Students should be able to know and understand relevant content, knowledge, principles, concepts, and theories, be able to demonstrate a specific set of skills and competencies and display appropriate attitudes and values [35]. This implies that a verb such as “understand” that is so often used as a cornerstone for many learning outcomes should be replaced with verbs such as “identify”, “apply”, “analyze”, “compare”, “evaluate” [33] and “calculate” [36]. Yes, learning outcomes must express in operational terms what students should be able to demonstrate or achieve for purposes of assessment [37]. Learning outcomes need to drive modules and be designed within proper guidelines in order to promote intellectual thinking and higher levels of applications among students [38].

Learning outcomes also need to be sustainable! To create sustainable learning outcomes, the design of the learning occasions has to take into account the knowledge and experience of the individual learner or learning groups [39]. In particular, questions relating to the internationalization of content and learning outcomes needs to be addressed [40]. These statements make clear that learning outcomes need to be interpreted and understood from one student group to another, across universities from one country to another. Furthermore, lecturers need to understand what students need and want and efficiently offer knowledge that makes the student more global in line with international educational goals [41].

Subsequently, in the context of this study, a sustainable curriculum is defined as one where its learning outcomes are clear, concise, measurable, manageable, reasonable and sustainable, being interpreted in **the same way** between registered students from different cohorts and between academics from the same department. The design principles mentioned above as well as the definition of a sustainable curriculum were applied to a telecommunications module which serves as the case study for this research.

CASE STUDY – A TELECOMMUNICATIONS COURSE AT A UNIVERSITY OF TECHNOLOGY

Electronic Communication Systems 4 (EKS4) is an optional offering or module for the Baccalaureus Technologiae (BTech: Engineering: Electrical) qualification in South Africa [42] Table 1 outlines the module structure, syllabus and assessments. The syllabus and type of assessments of the module were not revised, but only the learning outcomes which were only 16 in total prior to 2014 (4 learning outcomes per theory section). Due to space constraints, only the original 4 learning outcomes for section 4 of the syllabus along with the 11 revised ones are shown in Table 2.

Students have to obtain a minimum of 120 credits for this qualification to be awarded the BTech: Engineering: Electrical degree. The majority of modules in this BTech programme have a credit value of 12 (this means that students should dedicate at least 120 notional hours to this module), with the exception of a capstone module (termed Industrial Projects 4) which has 36 credits attached to it. The Central University of Technology (CUT) operates on a semester basis of roughly four months during which time BTech students attend one night class per week (5 periods, each of 45 minutes in duration) over a 12 week period for the EKS4 module. Electrical engineering students need to be in possession of a National Diploma (minimum of 3 years to complete) before they can register for the BTech programme which can be completed within a year if they are enrolled full-time.

Table 1: Module structure and assessments

Qualification	**BTech: Electrical: Engineering**	**Structure from 2014 onwards**
Syllabus (theory sections)	1. Digital transmission of analogue signals 2. Communication systems 3. Spread Spectrum Systems 4. Error Control Coding	1. 16 learning outcomes 2. 20 learning outcomes 3. 9 learning outcomes 4. 11 learning outcomes
Formative assessments	2 x written classroom tests where Test 1 contributes 25% and Test 2 contributes 40% to the total course mark	• Test 1 includes 25 marks from section 1 and 2 • Test 2 includes 25 marks from section 3 and 4
Practical work	4 x practical assignments which are submitted online which contribute 35% to the total course mark	Each practical is linked to a theory section
Summative assessment	1 x closed book examination where the student's final mark comprises 40% of the total course mark and 60% of the examination mark	25 marks per theory section covered in the examination

Table 2: Original outcomes versus the revised outcomes for theory section 4 in the syllabus

Syllabus theory section 4	**Original 4 learning outcomes prior to 2014**	**Revised learning outcomes from 2014 onwards**
Error Control Coding	1. Describe and analyze linear block and cyclic codes	1. Describe the purpose of linear block codes and cyclic codes 2. Analyze the block diagram of a digital communications system in terms of its main components and its purposes 3. Generate the parity bits for a given bit stream and evaluate any errors in reception 4. Generate the CRC code for a given bit stream using binary and polynomial division and evaluate any errors in reception
	2. Analyze the performance of convolutional encoder and decoder	5. Describe convolutional codes in terms of its operation and applications 6. Describe the operation of a convolutional code encoder and a Viterbi decoder
	3. Analyze the performance of turbo codes	7. Describe turbo codes in terms of its operation, decoding algorithm and applications 8. Describe an interleaver in terms of its operation and application
	4. Analyze the performance of low-density parity-check codes	9. Describe low-density parity check codes in terms of its operation, advantages and applications 10. Contrast coding differences between Turbo and LDPC codes 11. Analyze a tanner graph in terms of its equation and its generation

The EKS4 syllabus covers four main sections as shown in Table 1. A total of 56 revised learning outcomes were specified for this module which incorporated the verbs defining, describing, sketching, analyzing, calculating, designing, determining and evaluating. The last five verbs were used extensively in the assessments as it places particular emphasis on the higher levels of learning listed in Blooms Taxonomy which contribute to deep learning and critical-thinking [36]. Registered EKS4 students were asked to provide specific feedback on both the original and revised learning outcomes, as discussed under the following section.

RESEARCH METHODOLOGY

A case study was used in this research along with descriptive statistics to determine student feedback on revised learning outcomes. Descriptive statistics occurs where a specific situation is studied to see if it gives rise to any general theories [43]. The specific situation was the revision of former learning outcomes used prior to 2014 as compared to the new revised learning outcomes used in 2014 in a telecommunications module. The target population was restricted to all students enrolled for the EKS4 module during the second semester of 2014, therefore requiring no sampling technique. In order to ensure a successful and sustainable curriculum development, regular feedback from students about their views of the learning experience and outcomes is a must [44, 45]. A focus group interview was thus conducted at the end of the semester when all assessments had been concluded. The focus group interview covered questions relating to the original and revised learning outcomes in terms of them being clear, concise, measurable, manageable, reasonable and sustainable.

RESULTS AND DISCUSSION

Fig. 4 indicates the student profile of EKS4 for the second semester of 2014. The total number of registered students was 16. However, only 10 students completed the student profile and took part in the focus group interview, which was conducted during the final class of the semester, once all assessment results had been returned to the students. The majority of students were below the age of 30, being predominately male with the prevailing home language of Sesotho.

Fig. 5 (left hand side) highlights that the majority of students in the focus group felt that the original learning outcomes were vague (small triangle reveals that only one student felt that they were clear), as many stated that they would not really know what would be expected from them if these learning outcomes were stipulated at the start of the course. On the other hand, the revised learning outcomes were clear, conveying exactly what students had to achieve or demonstrate during the course or at its end.

Fig. 5 (right hand side) presents the results of student feedback regarding the conciseness of the original and revised learning outcomes. Again, the majority of students felt that only the revised learning outcomes were concise in terms of not featuring too many words and of getting to the point of what is required of them.

Fig. 6 (left hand side) shows the results regarding measurability of the learning outcomes. All the students in the focus group felt that the original learning outcomes were not really measurable, as many stated that if they do not know what is required, then they would not know how they would be assessed. On the other hand, all the students expressed the opinion that the revised learning outcomes were indeed measurable, as they knew exactly how they were to be assessed.

Fig. 6 (right hand side) depicts the responses of students with regard to the manageability of the learning outcomes. Both the original and revised learning outcomes are manageable in terms of numbers, although some students did indicate that they would prefer lower number of learning outcomes. This may correlate with what many professors are saying about their students who seem to be doing less homework these days, though there are always a few model students around [46]. However, students generally felt that the number of learning outcomes per section within this syllabus (which roughly covers a two week period within the semester) should not exceed 15.

Fig. 7 (left hand side) focuses on whether the learning outcomes were reasonable or realistic. Again, the majority of students indicated that the revised learning outcomes, which were roughly three times more than the original ones, were more reasonable and realistic, due to the fact that they clearly conveyed what is required. Students indicated that the original learning outcomes would take more time to decipher and understand, requiring more effort on their part to really come to grips with how they would be assessed.

Student feedback regarding the sustainability of the two sets of learning outcomes is given in Fig. 7 (right hand side). All the students felt that only the revised learning outcomes would be sustainable in terms of being clearly understood by future generations of students.

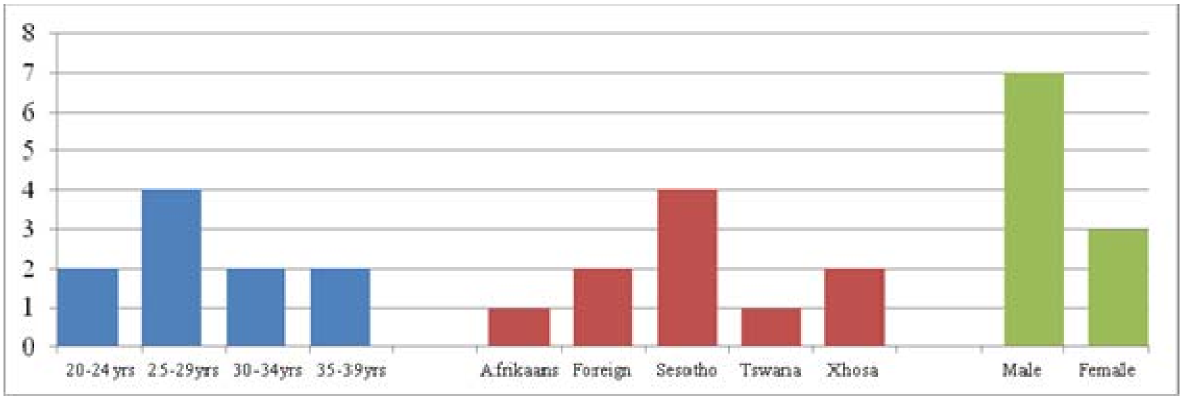

Figure 4: Student profile of the focus group in terms of age, home language and gender

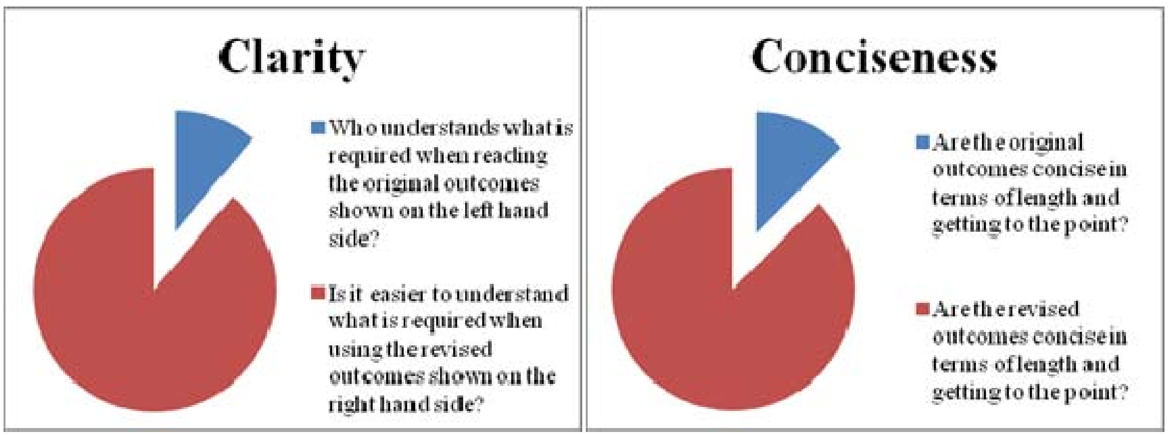

Figure 5: Student feedback on the clarity and conciseness of the learning outcomes

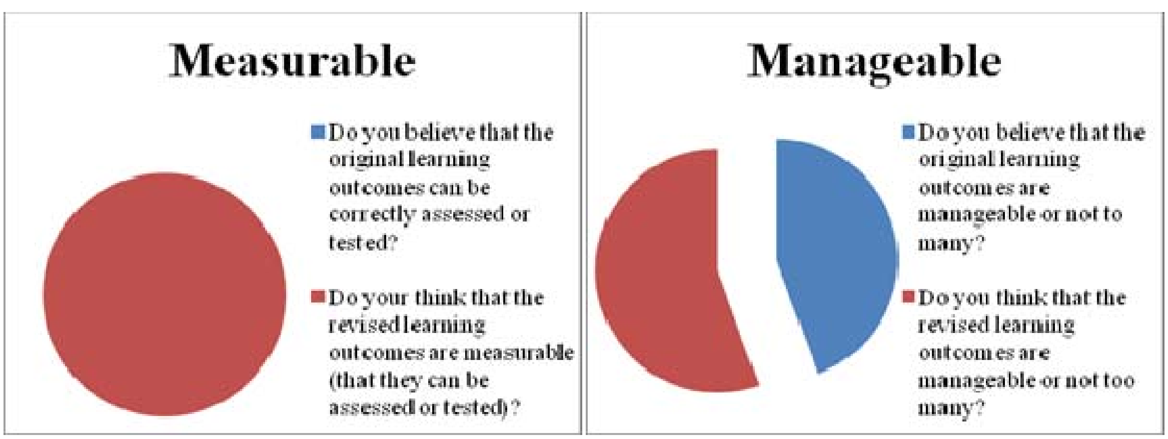

Figure 6: Student feedback on the measurability and manageability of the learning outcomes

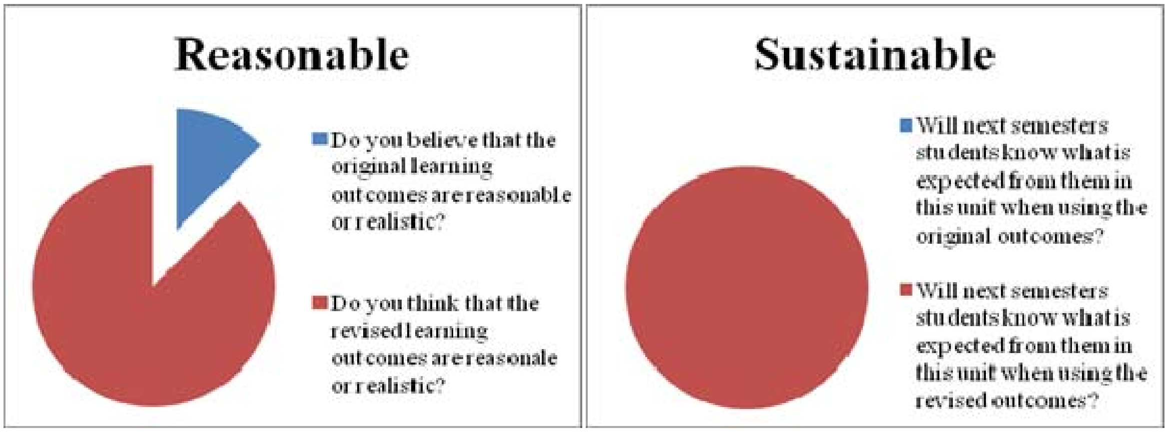

Figure 7: Student feedback on the reasonableness and sustainability of the learning outcomes

CONCLUSIONS

The purpose of this paper was to highlight how an engineering curriculum can be made sustainable in order to benefit both academics and students alike. It defined a sustainable curriculum as one where its learning outcomes are clear, concise, measurable, manageable, reasonable and sustainable, being interpreted in the same way between registered students from different cohorts and between academics within the same department. Student feedback indicated that the original four learning outcomes used prior to 2014 were vague, but manageable. The majority of students rather indicated that the revised learning outcomes implemented in 2014 were very clear, concise, measurable, reasonable and sustainable for future generations of students.

The sustainability of the learning outcomes where specifically defined in terms of their comprehension from one student group to the next, or from one student body at a specific university to the next study body at a different university. This same principle must be applied to academics. If an academic lecturing a specific subject had to leave the services of the university or become seriously ill, would his or her successor be able to take over the subject with the minimum amount of stress or uncertainty? Would the learning outcomes be easily understood by the academic, so that they would be able to teach or facilitate their new students effectively in a way that would promote active student learning? Would the learning outcomes specify to the academics what type of verbs to use in the assessment strategies, what pedagogical methods are needed and what content must be covered? Universities and academics need to ensure the sustainability of their engineering curriculums in order to leave no gap of uncertainty in terms of what students need to accomplish, no vagueness in terms of what students should be able to demonstrate and no doubt at all in the minds of academics of what they should be conveying to their current students. Academics need not be left-wing or right-wing people. They should just be concerned academics who are keenly interested in the sustainability of engineering curriculums at institutions of higher learning.

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REFERENCES

[1] Brainy Quote, Accessed on: 01 October 2014. Available at: http://www.brainyquote.com/quotes/, (2014).

[2] Z. Zhou, S. Cheng, and B. Hua, (2000) "Supply chain optimization of continuous process industries with sustainability considerations," *Computers & Chemical Engineering*, *24(2)*, pp. 1151-1158.

[3] J. C. Stephens and A. C. Graham, (2010) "Toward an empirical research agenda for sustainability in higher education: exploring the transition management framework," *Journal of Cleaner Production*, *18(7)*, pp. 611-618.

[4] P. Baughan, (2013) "Exploring the relationship between sustainability and university curricula: a small-scale study," *Learning at City Journal*, *3(1)*, pp. 54-64.

[5] A. Duff, T. Brodie, D. Furber-Gillick, D. Quinn, and E. Smith, (2011) "Do with and not to. Building cultural understanding, enabling communication and promoting the spirit of reconciliation in first year engineering,"

[6] A. Reid, (Year) "Internationalising Curriculum for Student Learning," in Australian Association for Research in Music Education: Proceedings of the XXIII Annual Conference, 2003, p. 111.

[7] P. Rickman, "Frankenfoods: Are We Bioengineering Our Children and What Can Curriculum Do?," DEd, College of Graduate Studies, Georgia Southern University, Georgie, 2012.

[8] A. Watson, K. Jones, and D. Pratt, (2013) "Key Ideas in Teaching Mathematics: Research-based guidance for ages 9-19,"

[9] S. K. U. S. Bukhari and H. Said, (2013) "Lack of Environmental Sustainability in Youth Training at Higher Education," *Journal of Education and Vocational Research*, *4(9)*, pp. 254-258.

[10] R. Donnelly, (2004) "Fostering of creativity within an imaginative curriculum in higher education," *Curriculum journal*, *15(2)*, pp. 155-166.

[11] S. Y. Lam, (2008) "Teaching Engineering Surveying in a Civil Engineering Program: Curriculum, Pedagogy, and Assessment," *Journal of Professional Issues in Engineering Education and Practice*, *134(2)*, pp. 173-177.

[12] S. Niyozov and S. Bahry, (2006) "Challenges to education in Tajikistan: The need for a research based solution," *Educational Change and Reconstruction in Societies in Transition: International Perspectives*, pp. 211-32.

[13] D. Bok, *Our Underachieving Colleges*. Princeton: Princeton University Press, (2006).

[14] H. Khan, (2008) "The Central Role of Adaptation for Curriculum Enactment: Designing Educational Software for Adaptation of Curriculum Using Digital Library Resources,"

[15] T. F. van de Mortel, L. P. Whitehair, and P. M. Irwin, (2014) "A whole-of-curriculum approach to improving nursing students' applied numeracy skills," *Nurse Education Today*, *34(3)*, pp. 462-467.

[16] J. C. Richards, (2013) "Curriculum approaches in language teaching: Forward, central, and backward design," *RELC Journal*, *44(1)*, pp. 5-33.

[17] G. Wiggins and J. McTighe, *Understanding by design*. Upper Saddle River, NJ:: Merrill/Prentice Hall, (1998).

[18] R. M. Felder and R. Brent, (2003) "Designing and teaching courses to satisfy the ABET engineering criteria," *Journal of Engineering Education*, *92(1)*, pp. 7-25.

[19] J. Boniface, D. Read, and A. E. Russell, (2011) "Sharing learning outcomes in chemistry teaching at HE level: beneficial or detrimental?," *New Directions*, *7)*, pp. 31-35.

[20] L. E. Grinter, (1954) "Responsibility in engineering education," *The Journal of Higher Education*, *25(5)*, pp. 258-261.

[21] A. J. Swart, (2010) "Does it matter which comes first in a curriculum for engineering students – theory or practice?," *IJEEE, International Journal of Electrical Engineering Education*, *47(2)*, pp. 189-199.

[22] A. J. Swart, (2014) "Using problem-based learning to stimulate entrepreneurial awareness among senior African undergraduate students," *EJMST, Eurasia Journal of Mathematics*, *Science and Technology*, *10(2)*, pp. 125-134.

[23] L. Lawton, (2009) "An exercise for illustrating the logic of hypothesis testing," *Journal of Statistics Education*, *17(2)*, n2.

[24] P. T. Bhatti and J. H. McClellan, (2011) "A Cochlear Implant Signal Processing Lab: Exploration of a Problem-Based Learning Exercise," *Education, IEEE Transactions on*, *54(4)*, pp. 628-636.

[25] D. Santos-Martin, J. Alonso-Martinez, J. Eloy-Garcia Carrasco, and S. Arnaltes, (2012) "Problem-Based Learning in Wind Energy Using Virtual and Real Setups," *Education, IEEE Transactions on*, *55(1)*, pp. 126-134.

[26] L. R. C. Ribeiro and M. G. N. Mizukami, (2005) "Problem-based learning: a student evaluation of an implementation in postgraduate engineering education," *European Journal of Engineering Education*, *30(*pp. 137-149.

[27] E. L. Boyer, (1996) "The Scholarship of Engagement," *Journal of Public Service and Outreach*, *1(1)*, pp. 11-20.

[28] B. Bowe and M. Fitzmaurice, (2011) "Guide to Writing Learning Outcomes," *Dublin Institute of Technology, Dublin*,

[29] P. MacLean and B. Scott, (2011) "Competencies for learning design: A review of the literature and a proposed framework," *British Journal of Educational Technology*, *42(4)*, pp. 557-572.

[30] Y. Nurhamida, (2014) "Psychological Problem of Children Who Live in Poverty," *Research Report*,

[31] J. L. Nzilano, (2013) "Pre-service Teachers' Teaching Competencies: The Experience of Practising Teaching in Secondary Schools and Teacher Colleges," *African Journal of Teacher Education*, *3(1)*,

[32] M. Borrego and S. Cutler, (2010) "Constructive alignment of interdisciplinary graduate curriculum in engineering and science: An analysis of successful IGERT proposals," *Journal of Engineering Education*, *99(4)*, pp. 355-369.

[33] H. Larkin and B. Richardson, (2013) "Creating high challenge/high support academic environments through constructive alignment: student outcomes," *Teaching in Higher Education*, *18(2)*, pp. 192-204.

[34] L. Henrichsen and M. Tanner, (2011) "Creating Learning Outcomes for a TESOL Teacher Preparation Program," *TESOL Journal*, *2(4)*, pp. 394-422.

[35] T. R. Anderson and J. M. Rogan, (2011) "Bridging the educational research-teaching practice gap: Curriculum development, Part 1: Components of the curriculum and influences on the process of curriculum design," *Biochemistry and Molecular Biology Education*, *39(1)*, pp. 68-76.

[36] A. J. Swart, (2010) "Evaluation of Final Examination Papers in Engineering: A Case Study Using Bloom's Taxonomy," *IEEE Transactions on Education*, *53(2)*, pp. 257-264.

[37] F. Furedi, (2012) "The unhappiness principle," *Times Higher*, pp. 34-39.

[38] S. B. Khoza, (2013) "Learning Outcomes as Understood by" Publishing Research" Facilitators at a South African University," *Online Submission*, *3(2)*, pp. 1-11.

[39] H. Lukosch and P. De Vries, (2009) "Mechanisms to support Informal Learning at the Workplace", *Proceedings of ICELW*,

[40] L. Svensson and M. Wihlborg, (2010) "Internationalising the content of higher education: the need for a curriculum perspective," *Higher Education*, *60(6)*, pp. 595-613.

[41] E. Chung and C. McLarney, (2000) "The classroom as a service encounter: Suggestions for value creation," *Journal of Management Education*, *24(4)*, pp. 484-500.

[42] Central University of Technology, (2014) "Calendar 2014," in Programme Policy, ed. Bloemfontein.

[43] W. Goddard and S. Melville, *Research Methodology: An Introduction*, 2nd Edition ed. Lansdowne: Juta & Co, (2006).

[44] K. Sekhri, (2012) "Teaching methodologies in pharmacology: A survey of students' perceptions and experiences," *Journal of Education and Ethics in Dentistry*, *2(1)*, 40.

[45] A. A. Aziz, K. M. Yusof, and J. M. Yatim, (2012) "Evaluation on the Effectiveness of Learning Outcomes from Students' Perspectives," *Procedia-Social and Behavioral Sciences*, *56(*pp. 22-30.

[46] R. Or-Bach Mr, (2009) "IS education–An Empirical Study Of Individually Assigned Homework", *4th Mediterranean Conference on Information Systems*, Athens University of Economics and Business, 25-27 September

ABOUT THE AUTHORS

Name: Arthur James Swart

James completed an apprenticeship with Telkom SA in 1990, after which he worked as a telecommunications technician at De Beers Namaqualand Mines. He joined the Vaal University of Technology in 1995 and obtained a Master's in Education in 2007 and a DTech: Engineering: Electrical qualification in 2011. James has more than 10 year's academic experience in engineering education, having lectured various electronic communication modules at a University of Technology and an Open Distance Learning Institute. James has published more than 50 articles, papers and book chapters in the fields of electrical engineering (special emphasis on high-frequency Mosfet drivers and RF treatment of materials) and engineering education (special emphasis on assessment, integrating theory and practice and reflective practice) over the past 10 years. He is currently an Associate Professor at the Central University of Technology and remains very passionate about research, scientific writing and life-long learning.

Mailing address: Central University of Technology, Engineering Technology Building, Private Bag X20539, Park Roads, Willows, Bloemfontein, 9301
Tel: +27 51 507 3907
E-mail: aswart@cut.ac.za