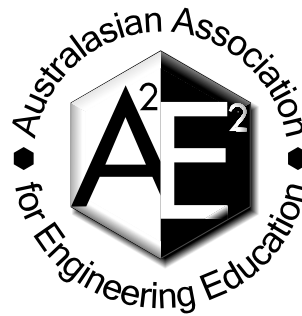


AUSTRALASIAN JOURNAL OF ENGINEERING EDUCATION



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Published in Australia by
The Australasian Association for Engineering Education Inc

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ISSN 1324-5821

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Papers published in the AJEE have undergone a formal process of peer review, with each paper being formally peer reviewed by at least two independent reviewers and the decision to publish is based on these reviews.

The correct bibliographic reference for this paper should include the web address where it was published:

Australasian J. of Engng. Educ., online publication 2005-02

<http://www.aeee.com.au/journal/2005/tavner05.pdf>

OUTCOMES-BASED EDUCATION IN A UNIVERSITY SETTING

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Abstract

Staff at UWA have been grappling with the issues raised by Outcomes-based education (OBE) since 2002. The difficulty of defining what is meant by outcomes and OBE is discussed, and the problems of attempting to introduce an outcomes-based approach into the existing University framework are identified. The short-comings of using outcomes to express higher-order skills and learning are discussed. Attempts to identify levels of achievement for some outcomes in the Mechanical Engineering discipline are reported, and this work suggests that a linear approach to levels of achievement does not reflect the non-linear way in which students learn. The paper concludes that an OBE approach does not seem well suited to the University teaching and learning environment.

Introduction

The basic tenets of Outcomes-based education (OBE) were propounded by Bill Spady, and are described by Williams (2004) as being about shifting the focus of educational activity from “teaching to learning; skills to thinking; content to process; and teacher instruction to student demonstration”. The University of Western Australia (UWA) has stated that it is committed to introducing outcomes-based education across its degree programmes (Treloar 2002). This report describes our deliberations on the subject of OBE while considering how to apply an outcomes-based approach to a stream of units offered by the School of Mechanical Engineering, teaching the combined subject areas of Thermodynamics and Fluid Mechanics (known colloquially as Thermofluids) across 2nd 3rd and 4th year of the Bachelor of Engineering Honours degree.

The Language of OBE.

The first problem we encountered was trying to understand the language that is associated with OBE, and in particular the word “outcome” itself. Jansen (1998) argues that “the language of innovation associated with OBE is too complex, confusing and at times contradictory”. He goes on to quote phrases from the South African National Curriculum Development Committee: “Transformational OBE ... is a collaborative, flexible, transdisciplinary, outcomes-based, empowerment-oriented approach to learning.”, which seems to prove his point. Berlach (2004) regards the language used in OBE as “the jargon of corporate business... it appears to be corporatisation applied

to education". David Prideaux also has difficulty with the language, and when attempting to explain it to colleagues feels "...some sense of unease that I am complicit in a process that imposes a level of complexity and technical jargon on what is a fundamental yet simple set of principles." (Prideaux 2000). However, the belief that the language of OBE is difficult is not universally held; Harden et al (1999) state: "The concept of OBE is easily understandable. It is not constrained by educational jargon and is a relatively simple and unambiguous concept." It is difficult to understand how they draw this conclusion.

Spady (Brandt 1992) defines an outcome as:

"the culminating demonstration of learning. It is a demonstration: what it is the kids will actually do... Outcomes are not content, they're performances".

This seems a reasonable definition, and bears some similarity to the idea of objectives. Willis and Kissane (1995) use more than 11 pages to explain the idea of an outcome, quoting a plethora of (at times conflicting) sources. Their discussion is complicated by different sources using the words "outcome", "objective", and "goal" to mean different things, or sometimes the same things. Daziell and Gourvanec (2003) contribute to the confusion: "At its most essential, OBE is a teaching and learning strategy that makes explicit to every student the goals or objectives of their education."

The difficulty of dealing with the specific terminology is demonstrated by Carter et al (2003), who appear to reverse the meaning of the terms outcome and objective for their own purposes: "Outcomes, then, provide an operational definition of the objective by rendering the objective teachable and measurable."

Williams (2004) defines the characteristics of outcomes: they should be achievable and assessable; instruction should make a difference; they should be essential to all learners; should be transparent and fair; they should indicate where learners have not achieved; and reflect the result of learning, not process. Spady himself is very clear that outcomes should state what students can do when they exit the system; outcomes for particular parts of a course are "checkpoints along the way... *enabling outcomes*. ...worth pursuing along the way to some larger exit outcome." (Brandt 1992). Willis and Kissane (1995) agree, regarding outcomes as relating to "the macro level of curriculum development, rather than the micro level."

Chip Bell, (Anon, 1991) sounds a note of caution about the language of OBE: "When we feel compelled to devise a new lexicon, and then start stumbling over what we mean, we're focussing on form not substance." ¹

Defining Outcomes-Based Education

Spady (Brandt 1992) defines OBE as consisting of four principles:

- (i) **Clarity of focus**, meaning that all activities (teaching, assessment, etc) are geared towards what we want students to demonstrate;

¹ This is an unusual example of a management consultant saying something useful. By coincidence, John Ralston Saul (1994) calls specialists in the science of education "the management consultants of the adolescent mind". This is probably not intended as a compliment.

- (ii) **Expanded opportunity**, meaning "expanding the ways and number of times kids get a chance to learn and demonstrate" a particular outcome;
- (iii) **High expectations**, "which means getting rid of the bell-curve", all students should achieve at the highest level;
- (iv) **Design down**, meaning designing the curriculum from the point at which you want your students to end up.

It is clear that OBE (in its original form) has much in common with Ralph Tyler's objectives model (Tyler 1949), which specifies that the curriculum for a course should be developed from a statement of principles (which became known as objectives) and describe how students' behaviour should change as a result of the learning experience. Prideaux suggests that narrow interpretation of Tyler's original model resulted in objectives only being described in behavioural terms, which made them difficult to write [and sometimes difficult to understand if you're not a behavioural psychologist] and limited the range of student skills and knowledge to that which could be expressed in behavioural terms. "Higher order thinking, problem solving, and processes for acquiring values may be excluded because they cannot be simply stated in behavioural terms." (Prideaux 2003)

UWA's Centre for the Advancement of Teaching and Learning (CATL) website offers assistance in creating and expressing outcomes which is *also* expressed in behavioural terms, and hence falls straight into the trap that made the objective model limited and difficult to use.

"The use of words to "understand" or "appreciate" are essentially useless as they do not convey what the student should be doing." (CATL 2004).²

We felt that some of the things we would want as outcomes from our units actually *are* understanding and appreciation.

Three things become apparent from a search of the literature on OBE. The first is that there is very little reporting of using an outcomes-based approach at University level. The exception to this is medical education, where outcomes have been used to develop whole curricula at certain Medical Schools, e.g. Dundee (Harden et al, 1999). Medical education is in many respects unique within the University environment, in that students finishing their Medical training³ must have a range of practical competencies as well as mastery of a considerable body of knowledge, and cognitive skills. The second thing that is apparent from the literature is that OBE is used to develop whole curricula, not to develop outcomes for individual units or streams. Spady's comments about *enabling outcomes*, mentioned above, confirm that. More worrying than either of

² The CATL website goes on to suggest ways of cutting-and-pasting outcomes statements together, which strikes me as an excellent way to generate "bland and decontextualised global statements" (Jansen, 1998), made up of "phrases tacked together like the sections of a pre-fabricated henhouse." (George Orwell, quoted by Watson (2003))

³ It is interesting to note that recent research into one of the most significant educational innovations of recent years, Problem Based Learning (originally championed by the Medical School at McMaster University) is suggesting that PBL doesn't do what it was intended to do, and doesn't give a reasonable return on investment. After using PBL for almost 40 years, McMaster are reworking their curriculum to return to more traditional teaching. (Gwee, 2004)

these is the absence of literature evaluating OBE, a deficiency also noted by Berlach (2004). Even allowing for the difficulty and complexity of evaluating a new educational paradigm, there should be more literature available confirming the success or effectiveness of OBE, unless of course it simply isn't effective.

Why take an outcomes-based approach?

Unfortunately, discussions within our School and Faculty indicate that this is a question that has not been asked, let alone answered with any clarity. Treloar (2002) asserts that: "Most state post-compulsory education systems have either adopted outcomes-based curricula or are in the process of doing so. These changes in the schools create an impetus for parallel changes within the universities." This is an outrageous non sequitur. Schools and Universities do not fulfill the same function, or deal with the same student demographic, so it does not necessarily follow that we should copy what is done in schools. It appears to many of the academic staff in our School that OBE has been imposed upon us with no consultation or debate. Spady comments "You cannot mandate OBE and hope to have it successfully implemented." (Brandt 1992)

The decision to move towards OBE at UWA looks curious when we consider what has been written and said about outcomes within the last few years. Holt (1994) damns the whole idea of OBE: "Education is not a product defined by specific output measures; it's a process, the development of the mind." This gives further weight to Berlach's (2004) view about corporate language being applied to education⁴. Donnelly (2002) argues that countries that do well in international comparisons of their schooling systems use a syllabus approach, not an outcomes-based approach to education. Wilson (2002)⁵ states that "Learning outcomes as now understood in Australia do not do what they were supposed to do: define expected student learning." He goes on to exhort his audience to "get beyond outcomes fetishism. The present form of outcomes has probably outlived its usefulness... our current form of generic outcomes should be given the chance to spend more time with its family." Wilson also argues that generic skills are the result of detailed study of a specific body of knowledge.

"My view is that much of the weakness of our current approach...arises because we want to shift... from facts to concepts; from recall and other lower-order skills to higher order skills; from the narrow boundaries of subjects to the more open territory of the cross-curricular and generic. In the process we have lost touch with reality. We have ignored millennia of development within and around disciplinary frameworks of exactly the kinds of higher order skills that we seek, and instead tried to develop a new epistemology with a generic basis... Transferable higher order learning, what I am calling deep understanding, is inseparable from a well-organised body of content knowledge which reflects a deep understanding of specific subject matter."

⁴ More specifically, this is the language of production engineering, which Ralston Saul (1992) and Watson (2003) point out is applied to every area of corporate and public life. This tends to give the impression that something worthwhile is being created, even when it isn't. See for example anything written by the financial services sector.

⁵ Bruce Wilson, CEO of the Curriculum Corporation of Australia. Donnelly (2004) describes him as "the person partly responsible for Australia's adoption of OBE."

This view directly opposes Spady's vision of OBE (Brandt, 1992): "should kids take a separate course called history every year that starts at some ancient time and moves forward to the present? No." Here is Wilson (2002) again: "Some KLAs [Key learning areas] don't work ... so, get rid of them in favour of the important constituent parts ... in SOSE [Studies of Society and the Environment] these are History and Geography." Wilson is also in opposition to the view expressed by Willis and Kissane (1995): "Outcomes should provide broad descriptions of student competencies which reflect long-term learning of significance... superordinate to the details of the particular curriculum content." Jansen (1998) expresses similar concerns to Wilson's, stating that "OBE trivialises curriculum content even as it claims to be a potential leverage away from content... Children do not learn outcomes in a vacuum. Curriculum content is a critical vehicle for giving meaning to a particular set of outcomes."

Wilson's view has a profound resonance with my own; that we have largely succeeded in engendering higher-order skills in our students for many years, without needing to spell out what those higher-order skills were. McKernan (Fakier and Waghid, 2004) goes much further, arguing that:

"To have a fixed set of goals and outcomes, decided in advance, impedes the ability of the learner and educator to embark on the wonderful, unpredictable voyages of exploration that characterise learning through discovery and enquiry."

Fakier and Waghid (2004) go on to argue that an outcomes-based approach does not lend itself to the expression of complex outcomes.

"The depiction of a competence as a complex entity made up of simpler items of ability results in the atomisation of knowledge. A motorist never learns separately to change the gears, turn the wheel, control the pedals, and to judge the distance between the vehicle and the vehicle in front; all this happens as a coordinated whole. A complex skill such as driving entails a coordinated array of elements and cannot be defined independently of the rest."

Given that many of the outcomes we would be attempting to express in a University environment will be complex and interrelated, Fakier and Waghid's work suggests that an outcomes approach is not the best way to express what we hope to achieve. Jansen (1998) quotes from Richard Peters' book *Education and Ethics*:

"Worthwhile activities have their own in-built standards of excellence, and therefore can be evaluated according to the standards inherent in them rather than according to some end or outcome."

Jansen also concludes that "there is a fundamental contradiction in insisting that students use knowledge creatively, only to inform them that the desired learning outcomes are already specified."

Assessment

Any real attempt to introduce OBE requires a substantial overhaul of our traditional assessment techniques. Jansen (1998) describes this as

"the most potent mechanism... militating against curriculum innovation. ...Unsurprisingly, the international experience with OBE suggests that the assessment changes only moderately with outcomes-based innovation."

Brandt (Jansen, 1998) states that:

"Few schools [in the USA] appear to have reorganised their assessment and reporting schemes to reflect new, higher outcomes. More commonly, schools and districts draft outcomes based on the present curriculum or write ambitious and far-reaching new outcomes while changing their curriculum very little."⁶

This raises an extremely important issue: do we really intend to change the way in which we assess, mark, and rank our students? Jansen (1998) points out that for OBE to succeed even on a moderate scale, "radically new forms of assessment (such as performance assessment or competency-based assessment), classroom organisation which facilitates monitoring and assessment, [and] additional time for managing this complex process" are required. It is difficult to see how this could be achieved within our current University environment, and I feel that such substantial changes are far beyond my area of expertise.

Introducing an Outcomes based approach

Taking Spady's definition of OBE (Brandt, 1992), it is possible to see how close to OBE we can get.

- (i) Clarity of Focus. For all teaching and assessment activities to be aligned towards a set of outcomes – which should be exit outcomes, i.e. those we could expect our graduating students to demonstrate – requires that those outcomes exist in a suitable form. While it might be possible to combine the UWA educational principles⁷ (Appendix A), and the Engineers Australia attributes of a graduate⁸ (Appendix B) to generate a set of outcomes for engineering graduates (which must be achievable, assessable, etc.) this has not been done. In order to develop *enabling outcomes* for a unit or stream of units, the exit outcomes need to be decided first. Furthermore, alignment of all our activities will require considerable resources. The radical changes that would be required for assessment of OBE have been discussed above. Jansen (1998) points out that in addition to substantial re-training of teachers, teaching in an OBE context requires "new forms of learning resources (textbooks and other aids) which are consonant with an outcomes-based orientation."
- (ii) Expanded opportunity. Spady's intention is to give students numerous and varied opportunities to learn and to demonstrate that they have achieved outcomes; presumably exit outcomes or enabling outcomes. Spady also suggests that this system should be independent of time; students should be given as long as is necessary to learn and demonstrate. This is a very different system from our current one; pass-by-unit in 13-week semesters, and from the students' point of

⁶ Spady (Brandt, 1992) notes that writing a set of outcomes to fit an existing curriculum is not OBE. "Most of the recent history of OBE has involved people taking their existing curriculum and writing outcomes derived from it...we call this approach curriculum-based objectives." Willis and Kissane (1995) point out that relabelling or rephrasing "what were objectives as outcomes not only does not result in OBE, it is actually inconsistent with OBE."

⁷ UWA's educational principles were not written as outcomes in the OBE sense, and some fail the test of assessability: e.g. being a life-long learner could only be assessed at the point of death. (Curriculum council of WA, 1997)

⁸ Recent work by Tilli and Trevelyan (2005) has shown that the skills that engineers use during their working lives are not well understood. "We can conclude that there has been no recent, comprehensive investigation into the nature of engineering work as it is practiced." This suggest that the Engineers Australia attributes are at best well-intentioned guesswork.

- view, pay-by-unit. A time-independent system would require enormous cultural and organisational change.
- (iii) High expectations. Spady describes this as getting rid of the bell-curve, and ensuring that all students get to demonstrate their ability at the highest level. Wilson (2002) quotes recent research suggesting that all students are capable of learning the most complex and difficult concepts, but that this requires a substantial investment in teaching time, which takes us back to the issue of available teaching time in (ii) above, and the issue of resources in (i). How we deal with assessment has already been discussed. We cannot *get rid of the bell curve* without a substantial shift in the whole culture of University assessment. Our assessment mechanisms would need to look more like TAFE-style pass/fail competencies.
- (iv) Design Down. As mentioned above, this looks like Tyler's objective model, designing a curriculum from the end result rather than from "inputs" such as content. This is something that many staff at UWA have been doing for some considerable time, and many would agree that it offers a powerful way to focus the content and delivery of a unit on what is required at the end. By itself, Design Down is *not* OBE.

From OBE to a useable model

Considerable effort has been expended considering the many concepts and ideas that students need to grasp to do well in our introductory Thermofluids unit, Thermofluids 209. Over the last three years a hyperlinked database of more than 200 different terms that describe those ideas has been developed. (Spencer 2004) It is difficult to see how these concepts could be linked to a statement of outcomes that is achievable and assessable; in many cases an understanding of a single one of these concepts in isolation is meaningless, as they are all interlinked. For instance, an understanding of the term "temperature" is not separable from the idea of "heat". Any attempt to assess a thorough understanding of each of these terms individually would be extremely complex, time consuming, and of questionable value.

Other potential outcomes for students studying Engineering Thermodynamics for the first time are more obvious. For instance, an outcome⁹ associated with using thermodynamic tables could be developed along the following lines:¹⁰

Outcome: Use of thermodynamic tables.

Description: Students use the tables to retrieve data¹¹ to solve problems associated with the design and operation of steam plant and refrigeration plant.

⁹ This would of course be an *enabling outcome*, perhaps leading towards some final outcome associated with the mastery of a body of engineering knowledge.

¹⁰ Based on the model used by the Curriculum council of WA. The author worked on the focus group preparing the Engineering Studies course during 2002/2003.

¹¹ This pre-supposes that students recognise what the data actually is: they must already have a grasp of ideas like specific volume and density; internal energy, enthalpy, and entropy; superheated, saturated, and sub-cooled; as well as more obvious ideas like solid, liquid, vapour/gas. This raises the considerable problem of how inter-related outcomes could be expressed.

Elaborations:

- (i) Students understand the layout of the tables and are able to retrieve data from the relevant sections.
- (ii) Students are able to interpolate and extrapolate to obtain values not explicitly listed, and recognise when such interpolation or extrapolation is valid.
- (iii) Students understand the limitations of the data in the tables.

According to the tenets of OBE, the instructor now only needs to decide whether the student has achieved the outcome or not. Whether this means fulfilling the requirements of all/most/some of the elaborations is not clear. It may require the outcome *description* to be written in a more detailed way. Since all our current assessment systems require us to generate a mark or ranking of some kind, it would seem necessary to consider to what degree students achieve the outcome. Establishing "levels of achievement" for the outcome (and issues such as whether each of the elaborations requires its own statements describing levels of achievement) are considerably more difficult. Perhaps the base level for a "pass" at this outcome would be to use data from the tables to carry out a simple calculation (but as already mentioned, this would actually be assessing far more than the one outcome, as the student would require an understanding of what the data means). A higher level achievement could be to explain some of the apparent contradictions in the tables, or to explain why interpolation is not possible in some situations.

This brings us back to the issue of assessment within the University system. At the moment, we submit a single mark (a percentage integer) for each student at the end of a unit. If we are to assess in an outcomes-based way, we would need to collect marks based on some level of achievement in each of the outcomes (assuming this is possible). If these multiple marks are then collapsed into a single final mark, we immediately lose the richness of that information. We are also faced with the problem of exactly how to amalgamate these marks: how do we weight the different outcomes, or the elaborations of the outcomes?¹² In the example given above, it could be argued that the elaborations have been written in a hierarchical order already, with the lowest level of achievement first.

It should be remembered that as soon as we start to assign variable values to different outcomes, we're moving away from the original idea of OBE.

There has been considerable discussion within the engineering schools about how solving (mainly calculation-based) exam problems is a skill that many students appear to learn without a good conceptual understanding of the problem being solved. However, it was suggested to us that one of the problems with specifying the level of achievement from a (lower) mechanistic to a (higher) conceptual level, is that some students will have a good conceptual grasp of the problem but will *not* have mastered the (supposedly) lower-order problem solving process. We decided to test this hypothesis by setting some two-part exam questions which required students to:

¹² These issues are also being considered by the WA curriculum council and TISC [Tertiary Institutions Service Centre], who are faced with the problem of producing a single mark such as the TER [Tertiary entrance rank] from a vast array of results in individual outcomes across a range of school courses. This prompted a WA school teacher of my acquaintance to comment "OBE replaces one subjective judgement of a student's performance with lots and lots of subjective judgements of a student's performance."

- (i) use the thermodynamic tables to solve a straightforward calculation-based problem;
- (ii) explain why they had used data from various parts of the tables.

We have carried out this exercise with two large class groups (about 180 students each time). The results divide the students into four clear groups:

- (A) did well on both parts of the question;
- (B) did badly on both parts;
- (C) solved the problem well, but could not explain how;¹³
- (D) failed to solve the problem, but could explain how to obtain or derive all the data required from the tables.

Each time we tried this experiment, group D represented about 25% of the class. Obviously, the data fails to take account of students who might have run out of time, or not attempted one part of the question, however this is a sizeable group (about 45 students each year), and it is clear from the exam scripts that many of them have attempted both parts of the question. This appears to demonstrate that learning does not happen along a linear path from simple calculation to higher conceptual understanding. Perhaps this is not a new idea, but it calls into question many of the level-of-achievement statements developed by the WA curriculum council (which have been prepared by people with considerably more experience in developing OBE than I have).

The difficulty of writing outcomes for higher-level skills has already been commented on, but if we attempt to treat the UWA educational principles as outcomes an additional problem will arise: that of teaching and assessment. If these are outcomes, we must explicitly teach them and assess them. At the moment, I suspect that the educational principles are not explicitly taught, but develop in our students as a result of detailed study of specific content. If we choose to teach and assess them, we must be prepared for the additional workload that this would impose upon us.

Conclusions

This attempt to develop an outcomes-based approach to a stream of Thermofluids units has not been successful. The original aim of this work was conceived without an adequate understanding of the complexity involved in moulding the theory of OBE into a workable and useable model. I would like to emphasise that I approached this project with enthusiasm and anticipation, but as I delved further into exactly what OBE would entail, it became less and less appealing. Ultimately I am left wondering why we would adopt an educational model which is so obviously unsuitable.

From an educational perspective, it is difficult to see why UWA should choose to adopt OBE; a system that requires such a radical re-think of teaching, learning and assessment, that the administrative burden alone will ruin its chances of success. Furthermore, OBE was conceived as a system for schools, where students with widely differing academic abilities are each taught a wide range of subjects.

¹³ This is also testing the students' ability to explain themselves in writing, which could be another outcome for this unit, but then of course we'd have to teach that as well. How do we then separate the different tests of the various outcomes that might be required to complete one small piece of work, or in this case, answer one exam question?

Critics of OBE have expressed misgivings about the suitability of OBE for expressing higher-order skills and the complex interaction between them, and attempts to describe even simple outcomes in the Thermofluids area have shown that the level of complexity required is unmanageable.

Work by the author has demonstrated that a linear level-of-achievement model for individual outcomes does not reflect the non-linear way in which students learn. Even using a simplistic linear approach will lead to an outcomes structure of unmanageable complexity. A comprehensive outcomes structure containing outcomes based on knowledge of specific content will be such an elaborate, complicated and artificial construct that it will bear no relation to the real-life learning experiences of our students.

Considering Spady's original four-point description of OBE, the sole useable facet (in the University context) is the design-down approach to developing curricula, which by itself does not constitute OBE, and looks much more like Tyler's original objective model (Tyler 1949.)

Introducing OBE, even in the type of half-baked form that might actually be possible in the University environment, runs the risk of imposing a bland uniformity on everything that we teach, removing the diversity and richness associated with different units being approached, described, taught, learned and assessed in different ways; surely a better "educational experience" and preparation for life after University.

If we really want to improve education (and if that isn't what OBE is intended to do, why are we even discussing it?¹⁴) we should perhaps listen to Donnelly (2004) "The most effective way to improve educational performance is... to ensure that what happens in the classroom is based on sound research."

¹⁴ Of course, OBE might be being imposed upon us for other reasons. "Outcomes, as distinct from the more general statements of educational intent like aims and objectives, provide a means of system and organisation accountability because they are overt, observable and therefore assessable indicators of student achievement. Such accountability has become part of an economic agenda which prompted the emergence of the national curricula in both England and Wales, and Australia." Brady (1997). Berlach (2004) warns us that "the death of knowledge occurs when the evidence of learning is more important than the learning itself."

Acknowledgements

Thanks to the Thermofluids team in the School of Mechanical Engineering at UWA: Dr Laurence Spencer, Dr Kamy Cheng, Dr Melinda Hodkiewicz, and my other colleagues throughout the University who have spent so much time discussing teaching, learning and the issues of OBE with me.

Thanks to the University Teaching and Learning Committee at UWA for providing the funding which allowed this work to be carried out.

Thanks to Ms Claire Chinnery of CTEC at UWA, who has provided much useful information about teaching, assessment and evaluation in Medicine, and provided valuable feedback on this report.

Thanks to Mr Rod Beresford at the WA Curriculum Council, who spent considerable time in front of a whiteboard patiently explaining how their model of OBE is intended to work.

Quotations

Outcomes-based education will not be fully implemented at UWA within the lifetime of anyone in this room. – Senior UWA academic.

The introduction of outcomes-based education into years 11 and 12 in New Zealand has ruined a perfectly good education system. – Senior executive of the Taylor's Group

Outcomes-based education? Just say No! It's just a way of making sure that nobody fails. – English teacher in WA government school.

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Appendix A

UWA's educational principles, an extract from the University of Western Australia Strategic Plan, available online at:

http://www.registrar.uwa.edu.au/__data/page/65557/Strat-Plan-2001.pdf

Students at The University of Western Australia are encouraged and facilitated to develop the ability and desire:

- to master the subject matter, concepts and techniques of their chosen discipline(s) at internationally-recognised levels and standards;
- to acquire the skills required to learn, and to continue through life to learn, from a variety of sources and experiences;
- to adapt acquired knowledge to new situations;
- to communicate in English clearly, concisely and logically;
- to acquire the skills needed to embrace rapidly-changing technologies in a global environment;
- to think and reason logically and creatively;
- to undertake problem identification, analysis and solution;
- to question accepted wisdom and be open to new ideas and possibilities;
- to acquire mature judgement and responsibility in ethical, moral, social, and practical, as well as academic matters;
- to work independently and in a team;
- to acquire cross-cultural and other competencies to take a citizenship and leadership role in the local, national or international community.

Appendix B: Engineers Australia generic attributes of a graduate.

Graduates from an accredited program should have the following attributes:

- ability to apply knowledge of basic science and engineering fundamentals;
- ability to communicate effectively, not only with engineers but also with the community at large;
- in-depth technical competence in at least one engineering discipline;
- ability to undertake problem identification, formulation and solution;
- ability to utilise a systems approach to design and operational performance;
- ability to function effectively as an individual and in multi-disciplinary and multi-cultural teams, with the capacity to be a leader or manager as well as an effective team member;
- understanding of the social, cultural, global and environmental responsibilities of the professional engineer, and the need for sustainable development;
- understanding of the principles of sustainable design and development;
- understanding of professional and ethical responsibilities and commitment to them; and
- expectation of the need to undertake lifelong learning, and capacity to do so.

Taken from the Engineers Australia accreditation manual, available online at:

<http://www.ieaust.org.au/membership/res/downloads/AccredManual.pdf>

About the author

Angus Tavner was educated in the UK, and received his BSc(Hons) in Mechanical Engineering and his PhD from the University of Southampton. He was a lecturer at the Institute of Cryogenics and then the Department of Mechanical Engineering at Southampton. Following a brief spell in the pipeline services industry in the UK, he joined the School of Mechanical Engineering at the University of Western Australia in 1999. He is the Faculty advisor to the UWA Formula SAE team, and Coordinator of Undergraduate Studies for the School.