Facilitutor – more than a trivial merging of a facilitator and a tutor

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BACKGROUND
Engineering educators are increasingly introducing non-traditional pedagogies into curricula. In Australia, New Zealand, the US, and Europe many engineering educators have combined, and in rare cases replaced, traditional lectures, tutorials and laboratory sessions with learning experiences such as problem or project-based learning and interactive learning. These alternatives are designed to achieve many improvements including better resembling engineering practice, encouraging deep approaches to learning, developing personal and practical competencies along with theoretical understanding, and improving motivation by providing context.

Implementing non-traditional pedagogies carries risk. Designing new curricula is time consuming. Teaching small classes is expensive. Until these methods become commonplace, students are likely to be cautious, if not resentful, when they discover that their experience at university is not the traditional experience they expected. Competent teachers are an essential ingredient to giving students an excellent opportunity to learn. Therefore, it is crucial, along with a new curriculum design, that we have a clear definition of the new role of teachers, and an understanding of the attributes of an effective teacher in the new curriculum. Only in this way can we select the best people for the new role and appropriately train these people to perform the unfamiliar role.

The University of Western Australia introduced a new 3 + 2 (engineering science major + professional engineering major) curriculum in 2012 (Trevelyan, Baillie, MacNish, & Fernando, 2010). In first semester 2012 the four engineering foundation units were taught in facilitated interactive workshops of 20 to 30 students. These workshops replaced traditional lectures, tutorials, and laboratory sessions. Each unit integrated traditional engineering foundation content (Male, Guzzomi, & Baillie, 2012).

PURPOSE
This paper defines and explores the new teaching role, “facilitutor”, required to teach in interactive workshops that replace lectures and in which engineering students learn through individual preparation and interactive activities with their peers.

DESIGN/METHOD
As part of the earlier curriculum development, threshold concepts in the integrated engineering foundation course were identified and investigated through interviews, focus groups, and workshops with engineering students and academics (Male & Baillie, 2011a, 2011b). In this study we analysed the identified threshold concepts to identify those that facilitutors can help students develop.

RESULTS
A facilitutor must be skilled at encouraging and helping students to learn independently and interactively. However a facilitutor must also have an excellent understanding of engineering concepts and skills across the traditional engineering disciplines within each of the foundation units.

CONCLUSIONS
The role of the facilitutor is more than a merging of the roles of tutors and facilitators. It requires deep and broad engineering competence and skills and not a trivial labelling of tutors as facilitators.

KEYWORDS
Facilitutor, engineering education, threshold concepts

Introduction

In Australia, as in New Zealand, Europe and the US, engineering educators, over the last decade, have been modifying teaching styles by replacing traditional lectures and tutorials with interactive learning activities for students (King, 2008). Students engaged in interactive learning activities are more likely, than those involved passively, to take a deep rather than a surface approach to learning and to be better prepared graduates for an uncertain future (Ramsden, 2003, p. 47). These activities are often designed to give students opportunities for hands-on experience that can improve learning, develop practical understanding and skills, and more closely resemble engineering practice than traditional curricula (Cameron, 2009). Interactive learning can also be designed to give students opportunities to develop graduate attributes such as communication skills, teamwork, and responsibility for safety and sustainability as must be developed in graduates for accreditation of engineering programs (ABET, 2011; EA, 2011; ENAEE, 2008). Further, it is valuable for students to experience engineering education that integrates traditional engineering curricula (Male, Bush, & Chapman, 2011) and technical and non-technical aspects of engineering competence (Male, 2010). Therefore arguments abound for engaging students in interactive learning in engineering.

Curriculum change carries risk for all stakeholders. In addition to short term issues such as cost, academics' time and effort, and students' and academics' angst that generally accompanies change, if the change is not proved successful or if a new teacher takes over without awareness of the benefits, engineering educators might revert to familiar teaching styles (De Graaf & Kolmos, 2007). Many have noted that changes to problem based learning (PBL), for example, demand more of the teachers and the students than traditional engineering education (Heywood, 2005, pp. 237-8). Heywood (2005, pp. 296-7) cites Courter's (1996) study of facilitators in a new course in design as demanding a profound learning process for the teachers. Most importantly, engineering educators have a responsibility to their students and to society to provide students with an excellent opportunity to learn and develop. With such responsibility, the risk, cost, and chance of the work being undone, it is essential that all steps are taken to ensure success of a new curriculum.

A critical aspect of engineering curriculum design is ensuring the quality of the teachers. This can be especially difficult if large cohorts are taught in small classes, as many teachers must be found and prepared for the role. A preliminary step is to understand the role and critical attributes of an effective teacher for the designed curriculum.

The University of Western Australia (UWA) introduced a new engineering science curriculum in semester 1 of 2012. The four engineering foundation units, Engineering Challenges for a Global World, Materials, Motion, and Energy, are integrative, meaning that each unit integrates traditional engineering curricula. These units are taken by students in the first and second years of the engineering science major. In first semester 2012 the units were taught in entirely interactive workshops. Students were asked to read material before attending class. They were not given lectures to present or re-iterate the reading material. Instead class time was used by the students in facilitated interactive activities to help them develop understanding. The approach included some project-based learning and problem-based learning in addition to many activities in which students solved problems in groups and then presented and justified solutions to their classes. Problem-based and project-based learning have been used extensively in other engineering programs (King, 2008; Kolmos, 1996; Mills, 2002). However, we are not aware of an engineering program that is taught the same way as the foundation units at UWA. Consequently, the role of teachers in this curriculum design had not been defined previously. With the increasing trend towards interactive learning in engineering, the definition is likely to contribute to engineering curriculum designs more generally.

In this paper, we name the teachers who take engineering workshops such as described above as “facilitutors”. It might seem that as the students are expected to learn by reading, accessing other resources, and teaching each other interactively in class, facilitutors might not require the depth of understanding previously required by lecturers. Instead, they would require skills as facilitator only. Furthermore, it was suggested that as the facilitutors were teaching engineering foundation units, the technical content would be well within the capacity of, if not familiar to, postgraduate engineering students from any discipline.

Researchers have investigated effective lecturing, tutoring, and laboratory demonstrating. Hazel and Baillie (1998, pp. 57-9) recommend that teachers in laboratories consider their “knowledge base”, including being well-prepared and familiar with the ideas, “facilitating not lecturing: trying to avoid telling students the facts but helping them to find out for themselves by asking questions”, “fostering student independence and growth:.. supporting students.. in high challenge situations; encouraging active participation”, “respecting students”, and “sharing enthusiasm”.

Using an example from a social theory tutorial, Lublin and Sutherland (2009, pp. 4-6) describe a facilitator as a tutor taking a tutorial built around questions and answers. This would need to be adapted for engineering in which problems often feature, but is relevant to the role of the facilitutor. “The tutor allocates students and questions to discussion subgroups… [and] encourages subgroups to compare and evaluate the results… during a whole class discussion… The tutor will help the whole class to see and make connections and to identify insights…The teaching roles are mainly… leader, facilitator, and clarifier”. Lublin and Sutherland note that tutors “provide role models for their students for operating in the discipline”.

Especially relevant to the role of facilitutor is the role of a facilitator in PBL. Krishnan (2012, p. 30) notes that a PBL facilitator has the roles of: monitoring the progress of the PBL process in groups; getting “students to discover for themselves if they are going down the wrong track, learn by making mistakes, and reason their way to conclusions”; “modelling good strategies for learning and thinking”; “scaffolding learning through the use of questioning”, “monitoring group processes”; “coaching” on working in groups; and using “a variety of questioning strategies”.

In this paper we address the following two questions.

What is the role of a facilitutor?

What are the attributes of an effective facilitutor?

Backgrounds of the researchers

We drew on our experience for insight necessary to undertake the analysis for this research. The second author co-developed the lesson plans and all course material for the foundation engineering unit, Motion, which integrates electrical engineering, fluid mechanics, and dynamics. He was a facilitutor for the unit in first semester 2012. The first author, with a team of academics, undertook the previous research, outlined below, to inform development of the four engineering foundation units. Both authors have engineering backgrounds and significant experience in engineering education research including authored journal papers in the field.

Theoretical Framework

A threshold concept framework (Meyer & Land, 2003) was used to focus learning in the engineering foundation curriculum at UWA, and forms the theoretical framework for this study. Threshold concepts in any discipline are those concepts that are transformative for students once understood and therefore act as gateways to students. They open ways of thinking and understanding necessary for progress in the course. Because these concepts are by definition transformative for many students, they are also troublesome for many students. It has been found that identifying and investigating threshold concepts can be an effective way to engage disciplinary academics in improving students' development of understanding of critical and troublesome concepts, and focusing otherwise crowded curricula (Cousin, 2010). Based on this theoretical framework, threshold concepts must be the focus of class-time, because these are the concepts most likely to be critical to students' progress and troublesome for students.

Meyer and Land (2005, pp. 375-7) describe the state experienced by a student when a threshold concept has come into view but remains troublesome as the "liminal space". When developing understanding of a specific threshold concept, some students pass easily through this liminal space. Many take a long time - perhaps years, and some students might never pass through the liminal space. Facilitutors must help give students opportunities to traverse the liminal space for identified threshold concepts.

Variation theory was behind the design of many of the interactive learning activities and the way they were facilitated in the new units, as recommended by Booth (2004) and Baillie, Bowden and Meyer (2012). Variation theory describes how students can learn by experiencing critical variation in critical features of a concept (Bowden & Marton, 1998). Variation theory is part of capability theory in which Bowden (2004, pp. 42-44) proposes that university students should develop capability to apply understanding to respond to unseen future demands. Based on variation theory and threshold concepts theory, the facilitutors were expected to give students opportunities to experience structured variation in critical features of identified threshold concepts, and help students to identify the insights gained from this variation by comparing and contrasting examples.

Previous research

In an earlier phase of the research, threshold concepts in the integrated foundation engineering units were identified in two phases undertaken over a similar period (Male & Baillie, 2011a, 2011b; Male, MacNish, & Baillie, 2012). In the diverging phase potential threshold concepts were identified by interviewing 16 academics and holding four focus groups with 20 students and student tutors in individual disciplines. Participants identified concepts they perceived to be threshold concepts and described their experiences that provided evidence for identifying these. This was named the diverging phase because many separate items were identified independently by participants in different disciplines during this phase. In the integrating phase, participants from multiple disciplines or universities negotiated potential threshold concepts. The integrating phase included a student workshop (N = 13), a student-staff workshop ($n_{students}$ = 7; n_{staff} = 8), four regional workshops attended by engineering teachers in Australia and New Zealand with over 100 participants, a workshop with 22 participants at the UWA, and workshops in Birmingham and Oxford.

Data were collected as: notes, completed hand-outs during workshops, and recorded transcripts of interviews and workshop group discussions. Data were analysed by identifying evidence of threshold concepts and how they can be transformative and troublesome, to iteratively develop an inventory of threshold concepts. Additionally, a final year student analysed 706 first year students' responses from two feedback surveys, identifying potential threshold concepts' from responses to open questions. Each item in the inventory includes how participants indicated that the threshold concept could be transformative, how it could be troublesome, and any suggestions for how to help students overcome the threshold concept (Male, 2012).

Three groups of overarching threshold concepts were identified: concepts required to learn to become an engineer (e.g. learning in diverse teams), concepts required to think and understand like an engineer (e.g. modelling and abstraction), and concepts required to shape the world as an engineer (e.g. integration of concepts).

Method

This paper reports analysis of the threshold concepts arising from the previous research outlined above. In this study the previously identified threshold concepts and their features were analysed to identify concepts that facilitutors could help students develop, and attributes that facilitutors would require to help students develop these concepts.

Findings and Discussion

It was initially assumed that facilitutors must have skills at facilitating, similar to those required to encourage active learning in a tutorial or laboratory session, and taking many roles of the PBL facilitator, as described in the Introduction. Through our analysis of the threshold concepts in which facilitutors were expected to help students develop understanding and capability, we identified the following facilitutor roles and attributes, confirming this initial assumption and additional roles and attributes.

Thinking and understanding like an engineer

Identified threshold concepts required to think and understand like an engineer include modelling, abstraction and theories, and concepts necessary for applying these. Some are shown in Figure 1. In the traditional curriculum previously at UWA, students were expected to develop capability in items low in the map, such as confidence in mathematical tools, through practice mainly in assignments and tutorials. In the new program at UWA, students are expected to practice problems outside class, and solve problems in groups in class, explaining and justifying various solutions, with the facilitator asking questions to help students experience variation.

Facilitutors must ask questions that encourage students to also develop capability in the concepts higher in the map, which often were neglected previously. For example, facilitutors might ask questions to help students understand that free body diagrams and control volumes or equivalent circuits are examples of system identification and share the common troublesome feature of being selected for convenience rather than being unique. Therefore facilitutors must have familiarity not only with concepts low on the map such as free body diagrams and equivalent circuits, but also concepts high on the map relating to relationships between free body diagrams and equivalent circuits.

Similarly, traditional problems completed by engineering students might have built confidence in mathematical tools through practice. However, relationships between physical and mathematical systems, which can be tacit for engineers and therefore neglected in curricula, have now been identified as threshold concepts and must also be in focus for students and faciltutors during lessons. In the active workshops, facilitutors must ask students probing questions to relate physical and mathematical representations, and engage students in drawing, explaining, and comparing visual and mathematical representations of systems and physical systems. Therefore the facilitutors must be familiar, not only with the detail of tools and specific representations, but also the significance and application of these.

Learning to become an engineer

Identified threshold concepts for learning to become an engineer included self-driven learning, roles of engineers, engineering as more than technical, confidence in ability to become an engineer, approaching open-ended problems, teamwork, communication and threshold concepts underlying these including the threshold concept that a team is more than the sum of its parts. These concepts, often perceived as generic, yet actually customised to engineering, are best developed while students engage in learning activities to develop the threshold concepts required to think and understand like an engineer, rather than separately from technical concepts (Male, 2010).

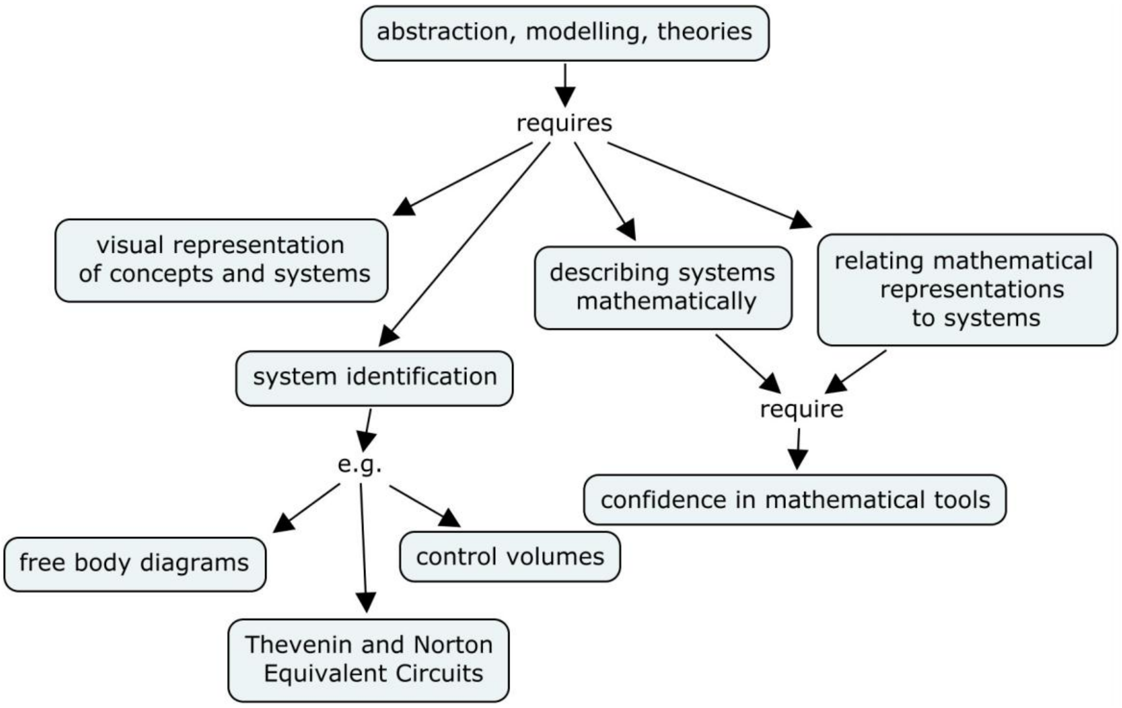

Figure 1: Some threshold concepts for thinking and understanding like an engineer

To encourage self-driven learning and confidence in ability, a facilitutor must be inclusive, avoid humiliating students, and ensure that students feel that they have control over their success. As noted in the Introduction, these are practices of effective laboratory demonstrators identified by Hazel and Baillie. To help students develop threshold concepts required for teamwork and communication, facilitutors must be role models, and coaches as described in the Introduction as necessary for a PBL facilitator and a tutor.

Based on variation theory, the new engineering foundation units are taught in a way in which students experience variation and experience teams achieving more than the sums of their parts. A common approach is to ask students to address a problem as follows. Students in a class of 20 to 30 students form groups of approximately five students. The facilitator poses a problem with multiple ways it could be addressed. In groups, students negotiate possible approaches to addressing the problem. Groups report their preferred approaches to the class. The groups negotiate the approaches. Groups then address the problem in different ways. For example different groups might use up to four different ways to identify an equivalent circuit. After each group has been nominated an approach to use, students first work individually. Each group then builds on the strengths of individuals in the group, draws representations of the group's solution on a board, and presents this to the class. Consequently the class builds on the strengths of the groups. The facilitutor helps the class recognise similarities, differences, and insights across the approaches.

In addition to coaching the students to work in teams and facilitating the discussions, for the above learning activity a facilitutor requires familiarity with multiple approaches and their relationships. There could be a group that struggles to use a chosen approach and requires guidance, or a group that uses an unexpected approach. To prepare for this unpredictable nature of the activity a facilitutor must have stronger familiarity with the concepts than for a planned lecture or even a traditional tutorial in which students solve a set of closed problems.

The threshold concept that engineering is about more than technical issues was previously found to be troublesome because it is contrary to many students' expectations. To help students develop understanding of roles of engineers and engineering as more than technical, a facilitutor will be well-placed if he or she has sufficient experience and awareness about engineering for the students to feel that they can trust the facilitutor's credibility. The facilitutor will also require the skills to help students link their learning to their experiences rather than expectations – an example of a concept that can be role-modelled which Lublin and Sutherland note as a role for all tutors.

Shaping the world as an engineer

Finally, some of the identified threshold concepts required by students to shape the world as an engineer are presented in Figure 2. These are high-level. Based on the theory it can be expected that a student requires time to pass through the liminal space between when the concept comes into view and when the student has developed thorough capability and acceptance of the concept. An academic in a regional workshop asked regarding the design process, "Do we teach this? Perhaps it is a threshold concept because we do not teach it." A final year chemical engineering student reported that the design process in his final year project was troublesome because it was the first time he had had to integrate topics from multiple engineering units. His design project in first year had not involved discipline-specific concepts because he had not yet completed any engineering units. If students need time to pass through the liminal space, then facilitutors will need to engage and coach students in design and underlying threshold concepts over extended periods. We expect that the facilitutor must have already passed through the liminal space required to develop these threshold concepts in order to guide the students.

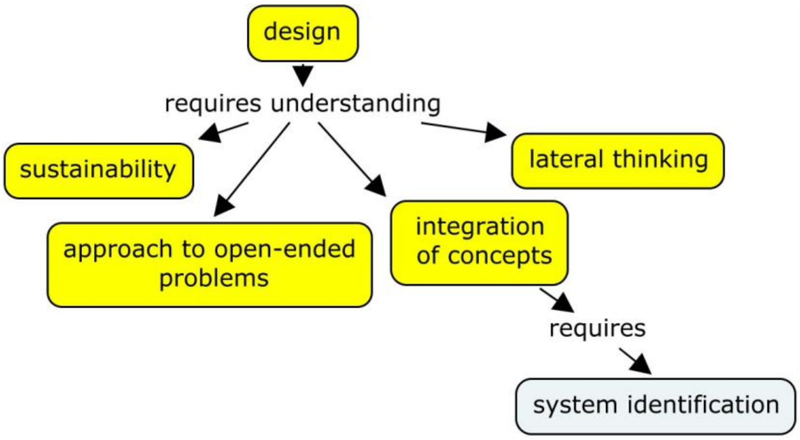

Figure 2: Threshold concepts required for shaping the world as an engineer

Conclusions

By analysing threshold concepts in the integrated engineering foundation we have found that facilitutors have highly demanding roles. Facilitutors must guide students to develop threshold concepts required to think and understand like an engineer. In addition to helping students experience variation in specific tools from multiple engineering disciplines, facilitutors must help students experience the variation required to develop understanding of the overarching threshold concepts, such as system identification, modelling and abstraction. This requires familiarity with specific concepts and big picture understanding of the different models, and the different manifestations of the concept in different contexts. The learning activities in the curriculum are unpredictable, placing the facilitator in unexpected situations requiring high-level capability in and around the threshold concepts.

Facilitutors must have sufficient experience and skills to help students develop: self-driven learning, confidence in their ability to become engineers, understanding of roles of engineering as more than technical, teamwork, and communication skills. These skills are consistent with the skills required for effective laboratory demonstrating, tutoring, and especially facilitation for PBL. The new curriculum at UWA is designed to build teams on the strengths of the individuals and classes on the strengths of the teams. The facilitutor can coach and facilitate the students to make the most of this opportunity.

Facilitutors must have sufficient experience to have already traversed the liminal spaces through which they must guide students. Threshold concepts required to shape the world as an engineer, such as design, are likely to be developed in students over extended periods of more than one semester or year of study. Therefore, facilitutors should be prepared to support students in high-level threshold concepts such as integrating concepts, design, sustainability, and approaching open-ended problems.

This analysis has provided insight relevant to selection of future facilitutors and has informed facilitutor training in semester 2, 2012. The role of the UWA engineering facilitutor is a new role different from traditional tutoring, lecturing, or demonstrating roles in engineering. The authors selected the term “facilitutor” to prepare engineering teachers and students for change. The threshold concepts previously identified had been negotiated around Australia and overseas. Relevance elsewhere will depend on pedagogy and other curriculum features.

This research provides a framework for improving the effectiveness of teachers by identifying and analysing the threshold concepts in a course. In this paper the three clusters of threshold concepts and some of their members are analysed. Analysis of the individual threshold concepts would yield further insights. Analysis should be complemented by learning theories. Further research will investigate students’ learning and students’ experiences of facilitutor practices in order to refine the role.

References

ABET. (2011). *Accreditation Policy and Procedure Manual Effective for Evaluation During the 2011-2012 Accreditation Cycle*. Baltimore, MD: Accreditation Board for Engineering and Technology.

Baillie, C., Bowden, J. A., & Meyer, J. H. F. (2012). Threshold Capabilities: threshold concepts and knowledge capability linked through variation theory. *Higher Education, online first*.

Booth, S. (2004). Why do student learn what they learn? In C. Baillie & I. Moore (Eds.), *Effective Learning and Teaching in Engineering* (pp. 7-24). Abingdon, Oxon & New York, NY: RoutledgeFalmer.

Bowden, J. A. (2004). Capabilities-driven curriculum design. In C. Baillie & I. Moore (Eds.), *Effective learning & teaching in engineering* (pp. 36-47). Abingdon, Oxon: RoutledgeFalmer.

Bowden, J. A., & Marton, F. (1998). *The University of Learning: beyond quality and competence*. London: Kogan Page.

Cameron, I. (2009). *Engineering Science And Practice: Alignment And Synergies In Curriculum Innovation*. Strawberry Hills, NSW: Australian Learning & Teaching Council.

Courter, S. L. S. (1996). *A grounded theory of the positive attributes of a TQM curriculum innovation. A multi-case study of a cross disciplinary course in engineering.* Unpublished doctoral dissertation, University of Wisconsin-Madison.

Cousin, G. (2010). Neither teacher-centred nor student-centred: threshold concepts and research partnerships. *Journal of Learning Development in Higher Education, 1*(2).

De Graaf, E., & Kolmos, A. (Eds.). (2007). *Management of Change: Implementation of Probem-Based and Project-Based Learning in Engineering*: Sense.

EA. (2011). *Stage 1 Competency Standard for Professional Engineer*. Barton, ACT: Institution of Engineering Australia.

ENAEE. (2008). *EUR-ACE Framework Standards for the Accreditation of Engineering Programmes*: European Network for Accreditation of Engineering Education.

Hazel, E., & Baillie, C. (1998). *Improving Teaching and Learning in Laboratories*. Jamison, ACT: Higher Education Research and Development Society of Australasia.

Heywood, J. (2005). *Engineering Education*. Hoboken, New Jersey: John Wiley & Sons.

King, R. (2008). *Addressing the Supply and Quality of Engineering Graduates for the New Century*. Surrey Hills NSW: Carrick Institute for Learning and Teaching in Higher Education.

Kolmos, A. (1996). Reflections on Project Work and Problem-based Learning. *European Journal for Engineering Education, 21*(2), 141-148.

Krishnan, S. (2012). Problem-Based Learning Curricula in Engineering. In M. Rasul (Ed.), *Developments in Engineering Education Standards: Advanced Curriculum Innovations* (pp. 23-40). Hershey, PA: IGI Global.

Lublin, J., & Sutherland, K. (2009). *HERDSA Guide Conducting Tutorials* (2 ed.). Milperra, NSW: Higher Education Research and Development Society of Australasia.

Male, S. A. (2010). Generic Engineering Competencies: A Review and Modelling Approach. *Education Research and Perspectives, 37*(1), 25-51.

Male, S. A. (2012, 9 August 2012). Integrated Engineering Foundation Threshold Concept Inventory. from <ecm.uwa.edu.au/engineeringthresholds>

Male, S. A., & Baillie, C. A. (2011a). *Engineering Threshold Concepts*. Paper presented at the SEFI Annual Conference. Retrieved 10 February 2012, from http://www.sefi.be/?page_id=24

Male, S. A., & Baillie, C. A. (2011b). *Threshold Concept Methodology*. Paper presented at the Research in Engineering Education Symposium.

Male, S. A., Bush, M. B., & Chapman, E. S. (2011). Understanding generic engineering competencies. *Australasian Journal of Engineering Education, 17*(3), 147-156.

Male, S. A., Guzzomi, A. L., & Baillie, C. A. (2012). *Interdisciplinary threshold concepts in engineering*. Paper presented at the Research and Development in Higher Education: Connections in Higher Education. Retrieved 9 July 2012, from http://www.herdsa.org.au/wp-content/uploads/conference/2012/HERDSA_2012_Male.pdf

Male, S. A., MacNish, C. K., & Baillie, C. A. (2012). *Engaging Students in Engineering Curriculum Renewal using Threshold Concepts*. Paper presented at the CDIO Conference.

Meyer, J. H. F., & Land, R. (2003). Enhancing Teaching-Learning Environments in Undergraduate Courses Occasional Report 4. Retrieved 31 May 2010, from http://www.etl.tla.ed.ac.uk/docs/ETLreport4.pdf

Meyer, J. H. F., & Land, R. (2005). Threshold concepts and troublesome knowledge (2): Epistemological considerations and a conceptual framework for teaching and learning. *Higher Education, 49*(3), 373-388.

Mills, J. E. (2002). *The effectiveness of project-based learning in structural engineering.* Unpublished PhD, Curtin University of Technology, Perth.

Ramsden, P. (2003). *Learning to teach in higher education* (2nd ed.). London and New York: RoutledgeFalmer.

Trevelyan, J., Baillie, C. A., MacNish, C., & Fernando, T. (2010). *Designing an Integrated Engineering Foundation Course*. Paper presented at the 21st Conference of the Australasian Association for Engineering Education.

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