Whole of Course Approach to ePortfolios and Engineering Competency Development

Neal Lake, Julienne Holt, Andrew Rose, Ricardo Vasquez Padilla and Maree Lake
Southern Cross University
Corresponding Author Email: neal.lake@scu.edu.au

CONTEXT
As part of each universities accreditation with Engineers Australia (EA) individual courses require documentation that demonstrates that each student on graduation has developed 16 elements of competency (Engineers Australia, 2016). This is usually achieved through constructive alignment, connecting the competencies with learning outcomes and assessment. However, this approach does not necessarily require the student to understand or engage with the EA Stage 1 competencies, thus missing many opportunities for learning through reflective practice and metacognition.

PURPOSE
This paper details the curriculum development of a whole of course approach to ePorfolios at Southern Cross University with the specific goals of developing a student's ability to understand their developed competencies in professionally relevant contexts and be able to articulate it in a variety of industry relevant mediums. The history and development of the engineering ePortfolio program is examined through reflections of the academic staff involved in the development and teaching of the program.

APPROACH
Based on the principle of making students explicitly aware of their developing competency and making them accountable for demonstrating it, the program focuses on developing the students' process and is strongly scaffolded in the first year. A competency development model was developed for the program and provides the basis for metacognitive awareness and the development of the students' reflective capacity. The ePortfolio program focuses on a fully integrated whole of course approach culminating in the final year capstone unit where student produce professionally relevant expressions of their developed competencies.

REFLECTIONS ON THE PROGRAM
The program has been constantly redesigned and refined based on feedback from staff and students. Initially developed based on formal reflective writing, the program was refined to incorporate the competency development model as a better way to engage students with the program. The program was also originally design to mimic the process to gain chartered professional status, however, the student outputs were found to be poorly backed up by context and evidence. The process was subsequently modified to represent the process to have a Stage 1 EA qualification recognised (career episode report). This provided a much strong basis for students to express their competencies.

CONCLUSIONS
The significant achievements of this program were to fully integrate ePortfolios and reflective practice into a whole of course design in a way that makes students explicitly responsible for understanding, developing and expressing their engineering competencies in a professionally relevant way. Core to this achievement was the development of the competency development model and the collaborative academic team approach.

KEYWORDS
ePortfolio, reflective practice, engineering competency development, whole of course.

Background

As part of each universities accreditation with Engineers Australia (EA), individual courses require documentation that demonstrates that each student on graduation has developed 16 elements of competency (Engineers Australia, 2016), which are deemed critical by Engineers Australia in order to be eligible to practice as a graduate engineer. The onus is on the education institution to demonstrate that graduating students have acquired the relevant competency elements. Accreditation is provided at course level and ensuring graduates have the necessary competencies is traditionally demonstrated using a constructive alignment approach to curriculum and assessment design.

Constructive alignment is a quality assurance framework that connects learning outcomes, teaching and learning activities, and assessment (Biggs and Tang, 2007; Biggs, 2014). Graduate Attributes or Qualities and professional requirements can be aligned (Faulkner, Aziz, Waye and Smith, 2013). If the EA Stage 1 competences are included in this mapping, then assurance that the student has developed the relevant competencies can be demonstrated through passing the course. Interestingly, and dependent of the specific university approach, it is possible for a student to complete an EA accredited degree without actually having any specific or detailed knowledge of the Stage 1 competencies. Unfortunately, this results in the loss of significant opportunities for self-reflection and professional capacity development for the student.

At the heart of capacity development is awareness of competency and the ability to reflect, self-assess, self-evaluate and plan for future personal capacity development. Many university engineering faculties have discussed the virtues of encouraging students to develop reflective capacity through the use of ePortfolios (Knott et al., 2004; Kavanagh and O'Moore, 2008). Falkner and Aziz (2011) also recognise the importance of holistic curriculum design and delivery that focuses on developing reflective and self-assessment skills. Aziz (2011) proposes an ePortfolio-based approach that stresses self-assessment and reflection to develop an evidence-based career episode report. However, the cornerstone to effective reflective practice is assisting students to understand and explore their own learning processes, and this must be actively and consciously taught.

Metacognition, learning to learn or metalearning (Biggs, 1985) lies at the core of reflexive pedagogy (Sonntag, 2006) with a focus on the processes rather than products of learning which supports students to develop awareness of their own mental processes. Importantly the role of the educator should be to make the implicit and tacit, explicit and articulated (Taffs and Holt, 2013) and embodied (Kinsella, 2007). This particularly relates to the development of professional and personal skills or 'soft skills', however, there is a recognised gap between industry expectations and students' perception of the exposure, preparation and level of expertise that is acquired at university (Itani and Srour, 2016). One of the ways that these skills can be strengthened in an engineering undergraduate course is for the lecturer's role to include that of teacher as leader, (Wolffe, et al., 2013), mentor (Stefani, Mason and Pegler, 2007) and as a facilitator of learning, modelling authentic professional practice. Central to this is to explicitly discuss and model 'thinking like an engineer' (Lucas and Hanson, 2014) for students.

Reflective practice, metacognition, thinking like an engineer and professional competency development are generally seen as critical to the students' professional development and require the student to become independently responsible for their learning. Persuading students to engage with these ideas and processes, however, can be challenging for the educator. Typically, the better students will see the benefits immediately and adopt the approaches necessary to advance. Weaker, less confident or resistant students however, will not as readily take up the approach without significant scaffolding (Stefani et al., 2007; Zubizarreta, 2009) and an assessment driven approach. Kavanagh and O'Moore (2008) called for a more systematic approach to incorporate and embed reflective practice in a

number of units across a course. Without continual engagement with the ideas and processes of reflection through a whole of course approach, the students may assume that it is not that important. Critically, it is also essential that lecturers model reflective practice to assist student to see the value in reflective practice for professional life.

ePortfolios provide a suitable framework to engage the students with the processes and ideas of reflective practice and capacity development throughout an entire course of study. This focus on process is best explored through developmental and scaffolded activities, tied to authentic assessment for learning tasks (Boud and Associates, 2010) with an emphasis on sustainable assessment to meet current and future self-assessment needs (Boud, 2000). Loughran (2002, p. 33) stresses the importance of the 'relationship between time, experience and expectations of learning' for effective reflective practice and the necessity to actively teach reflection as authentic practice. Stefani et al. (2007) also recognise the essential requirement of developing reflective skills over time. Hence, the early introduction of process driven, reflective practice, which then is developed and scaffolded over the whole of course, is central to effective teaching and fits well with a whole of course approach to ePortfolios. Wolffe, Crowe, Evens and McConnaughay (2013) make the important connection between reflective practice and using a capstone portfolio as a teaching method. They also recognise the importance of the process, not just the product, in the awareness of developing professional growth.

Kilgore, Sattler and Turns (2012) highlight the importance of ePorfolios to assist students to critically reflect on their learning, observing that making metacognitive awareness explicit provides a strong connection of engineering education with the transformational possibilities associated with lifelong learners. ePortfolios can be a powerful assessment and learning tool, provided that deep reflection, which goes beyond just recording, is deliberately and systematically introduced to students (Zubizarreta, 2009). The development of professional identity (Zou and Chan, 2016) and opportunities for making sense of experiences (Eliot and Turns, 2011) through experiential learning and critical reflection (Kilgore et al., 2013), which is scaffolded over time (Zubizarreta, 2009), are also essential outcomes of effective and integrated ePortfolios processes.

The challenge is to make this development of lifelong learning processes professionally relevant to students, both academically and as future professional engineers. The key to this is:

- Academics modelling the process
- Setting a professionally relevant basis for the ePortfolio
- Whole of course approach with authentic assessments that promote learning over time
- Strong developmental and scaffolded approach to help students understand the processes
- Making learners explicitly aware of their development competencies
- Connecting the ePortfolio with preparing professionally relevant documents such as the CV, selection criteria, preparing competency statements and preparing for behavioural interviews

Purpose

This paper details the curriculum development of a whole of course approach to ePorfolios at Southern Cross University with the specific goals of developing a student's ability to understand their developed competency in professionally relevant contexts, and be able to articulate it in a variety of industry relevant mediums. The history and development of the program is examined through reflections of the academic staff involved in the development and teaching of the program.

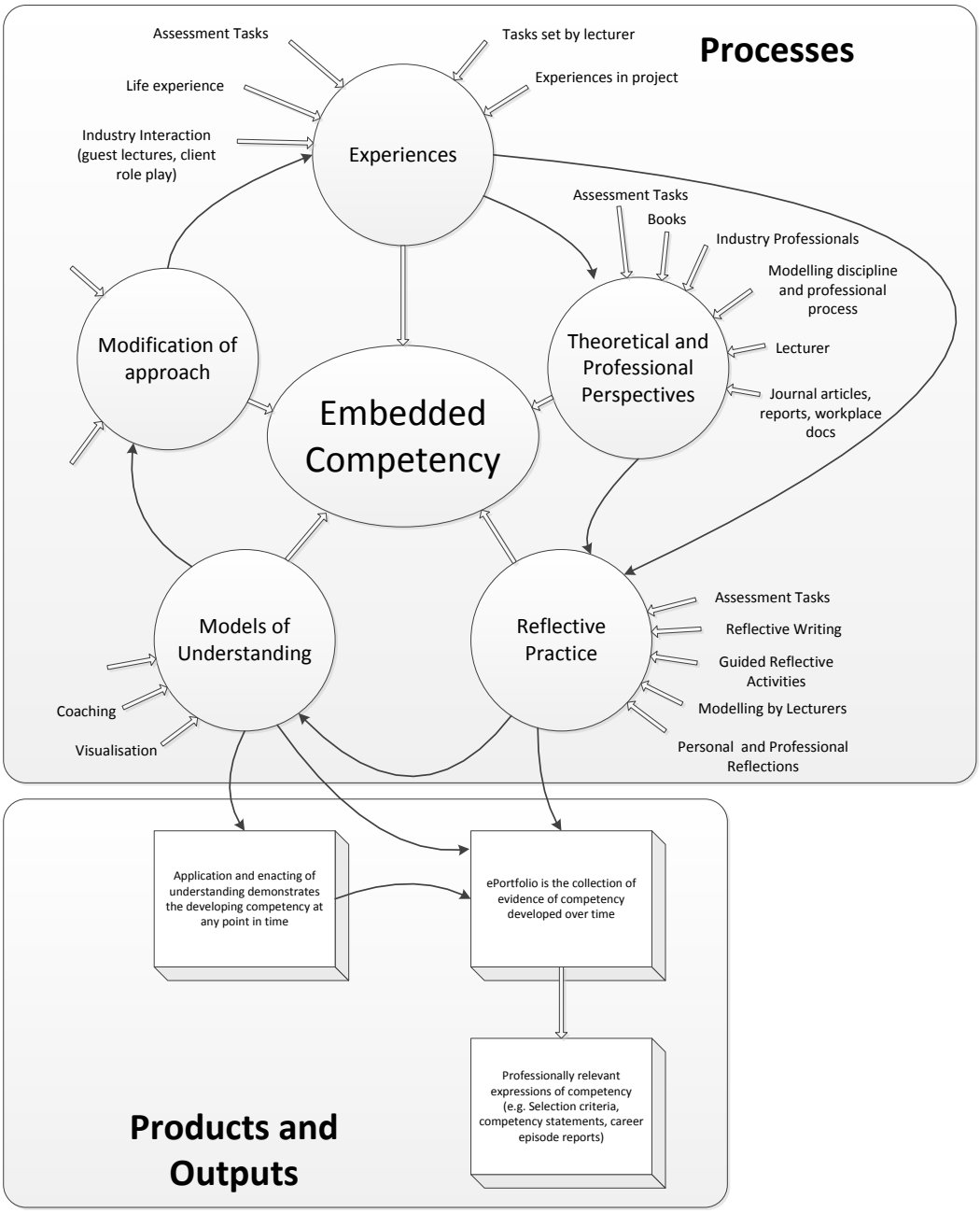

Figure 1: Competency development model

Approach

Design Principles of the ePortfolio program

Central to being a professional engineer is understanding the nature of one's own engineering competency. Therefore the cornerstone of the ePortfolio program is:

Making the students explicitly aware of their developing competency and make them accountable for demonstrating it through written and verbal formats.(Lake and Holt, n.d.)

In order to express competencies, students require many important lifelong learning skills such as self-reflection, self-evaluation, information management, career planning, which will assist them in their future professional lives. This is achieved using a scaffolded whole of course approach, where supporting activities and tasks are embedded throughout each

engineering degree at appropriate levels of development. Importantly an assessment framework is required to facilitate the development of these skills, because if it is not assessed students will not do it, so an assessment for learning approach is adopted.

The emphasis of the ePortfolio program is on developing students understanding of the processes of learning, and awareness of their developing competencies. In preparation for their professional work life, the focus is on developing their skills in problem solving and learning to become a reflective practitioner. As part of this process students collect, select and evaluate information, reflect and develop self-improvement plans that can feed into writing CVs, addressing selection criteria, preparing competency statements, and preparing for behavioural interview questions.

Competency Development Model

To engage students with the processes of developing competency, a Competency Development Model was designed for the program (Figure 1). The model is used to help students explore metacognitive, self-reflection, and evaluation principles as part of the process of developing competency and capacity. Competency is evolutionary in nature, so the model represents a cyclic and developmental approach to competency development over time. Importantly the student needs to integrate experiences, thus linking competency development to the process of lifelong learning. This awareness of, and control over, their learning processes is crucial to the development of professionalism and professional capability.

Central to the model is supporting students' self-awareness of their emerging engineering competencies. To assist this self-awareness, the concept of 'model of understanding' was developed as an accessible way to explore concepts of learning. Through visualisation (Figure 2) the students are encouraged to think about how the brain functions, the idea that new dendrites can be formed, modified, changed over time just like their own developing professional skills and attitudes. Students, with support from the lecturer as leader, mentor and facilitator, develop their own models of understanding of a particular subject or skill, based on their personal experiences, understanding of theoretical perspectives and critical reflective practice. This imagery assists the student to understand the process of capability development and enables them to link it in a real way their process of developing competencies.

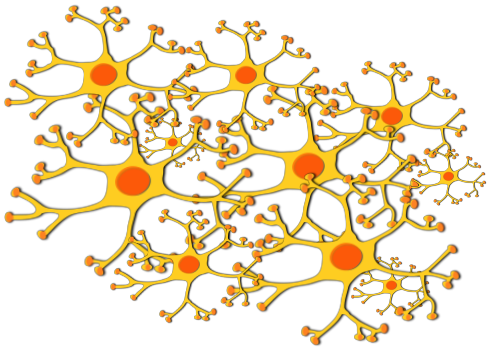

Figure 2: Imagery for 'models of understanding'

Whole of Course ePortfolio Program Design Paper

Scaffolded first year

The first year of the engineering program at Southern Cross University is highly scaffolded, exploring reflective writing skills, critical evaluation of capabilities and metacognitive awareness of competency development. This scaffolding is integrated and embedded into the introductory project engineering stream, consisting of two units: Processes and

Philosophy of Engineering and Humanitarian Engineering Project. These units employ an experiential, project based learning pedagogy, with an emphasis on using a team-based approach to solve authentic open-ended problems based around real projects. Competency Element 3.6, Effective Team Membership and Team Leadership, (Engineers Australia, n.d.) provides a basis to explore and scaffold the skills, attitudes and capabilities associated with competency development, with reflective exercises incorporated into the first year to build towards understanding and expressing competency. The first year stream culminates with the writing a career episode report by the end of the first year.

The first year focuses primarily on developing students' processes, but also enables them to experience the development of a product (career episode report) so that they understand the professional relevance of the ePortfolio. The first year breakdown consists of:

- *Lectures and class based activities:* Class based tasks on working as part of a team are set to use experience and facilitator observations to help students understand the dynamics of team operation. Aspects such as typical roles and the importance of effective facilitation and communication are discussed.
- *Reflective exercises on working as part of a team:* Student are assessed on a reflective writing piece that focuses on referencing a reading on teamwork and relating it to their experiences in their project teams. Students are also asked to discuss significant obstacles and strategies to overcome them to enable effective teamwork.
- *Visualisation exercise:* Students are taken through a guided visualisation exercise where that are asked to reflect on the team experience in the previous session. Then they are asked to develop a vision of a high performing and effective team, and their role in making this happen. Students are additionally asked to contrast the two images of past and the potential futures, and write down three things they can do differently to make their idealised vision of the future team based activity a reality. This then forms the basis of the first team meeting in the second unit, in which they discuss their overall team plan to execute the project.
- *Lectures on the development of competency and the competency model:* Students are introduced to the competency development model and the imagery around developing competency.
- *Report and reflection on high performance teams:* Students are asked to develop their own view of a high performance team based on critically evaluating relevant literature and their own experiences of working in teams.
- *Write a Career Episode Report:* focused on Stage 1 competency 3.6,1.5, 2.1, 3.3.
- *Develop an information retrieval system for their ePortfolio: in order to collect, collate and synthesise evidence of competency development.*

Middle years

The ePortfolio activities are primarily reflective assessment tasks to allow students to reflect on their progressive attainment of the Stage 1 Engineers Australia competencies over time, and collect the necessary evidence to use to produce expressions of competency. This focuses students on competency development processes and the self-evaluation required to drive continual improvement. The ePortfolio tasks are focused in units that typically end a sub-discipline course stream, however other units are included to ensure adequate coverage in all years of the course.

Final Year Capstone

The final tasks of the ePortfolio program and competency development model are to address all 16 EA Stage 1 competencies through the writing of a series of career episode reports. This significant task is weighted at 40% of the assessment mark of the double weighted Engineering Capstone unit in the final semester of study. The process used is modelled on the formal process used by Engineers Australia to assess eligibility for membership as a graduate professional engineer (Engineers Australia, 2016). The Engineers Australia process includes the preparation of Career Episode Reports (CERs) and the preparation of a summary statement, which cross-references the competency elements in their career episode reports (Engineers Australia, 2016). As part of the students' requirement for 60 days of industrial experience, the students are required to write a CER on each of their work experience appointments. Depending of the timing of these industry experiences, these CERs may also be incorporated in the final task of the ePortfolio program.

As the final stage of the ePortfolio, students have the opportunity to produce a number of other professionally relevant expressions of competency through the 'Ready grad program' offered by the Southern Cross University's careers development team. This is an intensive 4-day program where students undertake a number of workshops to prepare them for graduation. The students are required to write and present a CV with selection criteria statements. Mock interviews are also conducted to prepare students for the initial stages of professional life. This allows the students to put into practice the products of the ePortfolio program.

Reflections of the Program

Initially the program was presented to the students with a focus on formal reflective writing in the first year. As part of this approach, a guide to reflective writing was developed by the discipline academic and the academic skills lecturer to assist students with the process. Strong resistance was experienced from all but the most engaged students as most students struggled to make the connection between reflective writing and their future careers. The focus on reflective writing, rather than reflective practice, was one of the issues with this approach. The majority of successful engineering professionals engage in reflective practice as this forms the basis for improvement and development, however, very few would actually engage in formal reflective writing. This prompted discussions among the staff about what it means to be a reflective practitioner and how it is essential in professional life, and importantly how it can be set in a professionally relevant context for students. From this the idea, the competency development model was developed with a focus on producing professionally relevant expressions of competency.

Once the program was focused on competency development, the first year was then restructured to better scaffold the development of a particular engineering competency (teamwork) culminating in writing a competency statement. The competency writing format was originally modelled on the Stage 2 Engineers Australia (Engineers Australia, 2012) process used to gain chartered professional status, which involves writing 16 individual, 700 word competency statements to gain chartered engineering status. This approach was easy to justify to students as being professionally relevant as they will need to undertake this process early in their careers to gain chartered professional status. The problem however was that in a 700 word format, where competency can be demonstrated from multiple experiences, it becomes difficult to set the context and provide the relevant level of required detail. Thus, providing actual evidence becomes difficult within the word limit and competency statements can quickly degenerate into generalisation with little actual evidence to support the assertions. For this reason, the approach was modified to mimic the Stage 1 Engineers Australia competency assessment process used to assess non-accredited degrees. This process required the writing of a number a career episode report that are

longer and focus on a particular project or event. This format is much more suitable to developing a statement that uses evidence and context to develop competency.

Throughout the middle years of the program, staff reported that the students still struggled with effective reflective writing and connecting competency development to their study. There have been some exceptionally good responses to assessments, indicating that the tasks for some students were well understood. However, the majority of students did not demonstrate the connection of their experience with the development of engineering competency through reflection. This does not necessarily indicate that those students did not reflect on their competencies in a useful way, but their ability to do so in a systematic manner and report this effectively was often poor and remained underdeveloped. Thus the scaffolded first year has been progressively revised during the program and these changes are expected to support students in the middle years to improve over time. Key to this is engagement of academics in the program. Modelling of the processes needs to occur at all points throughout the program to assist the students to understand the purpose of the tasks and further develop their critical thinking and reflection skills. In addition, the importance of increasing the weighting of the ePortfolio tasks has been identified.

The capstone unit of the program has only been completed once in ePortfolio program. The task of writing career episode reports was received well by the students. In summative comments, the students identified that the task was difficult at the beginning but has been useful to prepare selection criteria and is a great way to refresh memories before a job interview. At the beginning, students thought it a waste of time, but after a while they realise the importance of the ePortfolio in their personal career and job applications. Overall, the level of engagement in the task was good.

From the first cycle of the program (four years), it was identified by staff that it would be beneficial to have an integrated system for students to store their experiences over the entire four years. Historically the use of a formal ePortfolio software system was not adopted because of uncertainty around licencing both in the short term and post-graduation, in addition to the steep learning curve associated with such software without adequate technical support. To date students have been responsible for storing their own materials, as this was seen as an important self-development step, however, the systems developed by students often lacked practicality and have not been effectively used. Storage systems do not need to be complicated. Simple systems using freely available software such as Evernote or OneNote can be effective, and it is proposed to provide more details on setting this up in first year rather than the current approach of letting the student propose and develop their own system.

Conclusions

This paper has presented a comprehensive whole of course curriculum design approach to using ePortfolios as the basis to collect, critically evaluate and synthesise student competencies, so that the student can express their competency in a professionally relevant way. Key aspects of this approach include the embedded nature of the skills throughout the course with a strongly scaffolded first year, and the final outcomes in the capstone 4th year unit which present opportunities for students to use their ePortfolios to produce professionally relevant documents such as CV's, selection criteria, statements of competency and enable preparation for behavioural interviews. Importantly the ePortfolio provides students for an opportunity for critical self-evaluation and development planning, thus helping the students to develop the essential lifelong learning skills critical to future professional success.

The significant achievements of this program were to fully integrate ePortfolios and reflective practice into the course design in a way that makes students explicitly responsible for understanding, developing and expressing their engineering competencies, thus creating a true whole of course approach that is professionally relevant. This achievement was only possible through a collaborative approach, where the academic team supported the program

and allowed activities to be embedded throughout the course. The competency development framework has set up a strong basis to engage student in their development of engineering competency and has established the foundation for developing their metacognitive awareness of competency development.

Key to long-term effectiveness of the program is designing and incorporating feedback from staff and students. Serious critical self-reflection on what worked and what did not is an integral part of the process, and has been extensively used to refine the program and ensure the professional relevance of the ePortfolio program.

References

Aziz, S.M. (2011). *ePortfolios to empower students in providing evidence of learning and professional development.* Paper presented at the Australasian Association for Engineering Education Annual Conference, Fremantle, WA.

Biggs, J. (2014). Constructive alignment in university teaching. *HERDSA Review of Higher Education, 1,* 5-22.

Biggs, J.B. (1985). The role of metalearning in study processes. *British Journal of Educational Psychology, 55*, 185-212.

Biggs, J., & Tang, C. (2007). *Teaching for quality learning at university.* (3rd ed.). Maidenhead, UK: Society for Research into Higher Education & Open University Press.

Boud, D. and Associates (2010). *Seven propositions for assessment reform in higher education*. Sydney: Australian Learning and Teaching Council.

Boud, D. (2000). Sustainable assessment: Rethinking assessment for the learning society. *Studies in Continuing Education, 22*(2), 151-167.

Eliot, M., & Turns, J. (2011). Constructing professional portfolios: Sense-making and professional identity development for engineering undergraduates. *Journal of Engineering Education, 100*(4), 630-654.

Engineers Australia. (n.d.). *Stage 1 competency standard for professional engineer*. Retrieved 9 November, 2014, from https://www.engineersaustralia.org.au/sites/default/files/shado/Education/Program%20Accreditation/110318%20Stage%201%20Professional%20Engineer.pdf

Engineers Australia. (2012). *Australian engineering competency standards stage 2 – Experienced professional engineer*. Retrieved 9 November, 2014, from https://www.engineersaustralia.org.au/sites/default/files/shado/Education/Program%20Accreditation/110318%20Stage%201%20Professional%20Engineer.pdf

Engineers Australia. (2016). Stage 1 competency: Eligibility for membership guide. Retrieved 27 July, 2016, from https://www.engineersaustralia.org.au/sites/default/files/professional_engineer_stage2competency_approved.pdf

Faulkner, M., & Aziz, S.M. (2011). Stimulating self assessment and reflection in first year engineering using ePortfolios. *Journal of the Education Research Group of Adelaide, 2*(2), 5-17.

Faulkner, M., Aziz, S.M., Waye, V., & Smith, E. (2013). Exploring ways that ePortfolio can support the progressive development of gradual qualities and professional competencies. *Higher Education Research and Development*, *32*(6), 871-887.

Itani, M., & Srour, I. (2016). Engineering students' perceptions of soft skills, industry expectations, and career aspirations. *Journal of Professional Issues in Engineering Education and Practice, 142*(1), 04015005-1 – 11.

Kavanagh, L., & O'Moore, L. (2008). *Reflecting on Reflection – 10 years, engineering, and UQ.* Paper presented at the Australasian Association for Engineering Education Annual Conference, Yeppoon, QLD.

Kilgore, D., Sattler, B. & Turns, J. (2012). From fragmentation to continuity: Engineering students make sense of experience through the development of a professional portfolio. *Studies in Higher Education, 38*(6), 807-826. doi:10.1080/03075079.2011.610501

Kinsella, E.A. (2007). Embodied reflection and the epistemology of reflective practice. *Journal of Philosophy of Education, 41*(3), 395-409.

Knott, T.W., Lohani, V.K., Griffin, O.H., Loganathan, G.T., Adel, G.T., & Wildman, T.M. (2004). *Bridges for engineering education: Exploring ePortfolios in engineering education at Virginia Tech.* Paper presented at the American Society for Engineering Education Annual Conference & Exposition, USA.

Lake, N., & Holt, J. (n.d). *Designing Quality Engineering Curricula to Produce Industry Ready Graduates: A whole of course approach*, Higher Education in the Professions: Case Study Illustrations of Quality Practice, Edited by Fernando Padro, Karen Trimmer, David Thorpe & Tara Newman.(Not yet published)

Lucas, B. & Hanson, J. (2014). *Thinking like an engineer: Using engineering habits of mind to redesign engineering education for global competitiveness.* SEFI, 42nd Annual Conference. Birmingham, UK.

Loughran, J.J. (2002). Effective reflective practice: In search of meaning in learning about teaching. *Journal of Teacher Education, 53*(1), 33-43.

Sonntag, M. (2006). Reflexive pedagogy in the apprenticeship in design. *European Journal of Engineering Education, 31*(01), 109-117.

Stefani, L. Mason, R., & Pegler, C. (2007). *The educational potential of e-portfolios: Supporting personal development and reflective learning.* Abingdon, Oxon; New York, N.Y.: Routledge.

Taffs, K.H. & Holt, J.I.(2013). Investigating student use and value of e-learning resources to develop academic writing within the discipline of environmental science. *Journal of Geography in Higher Education, 37*(4), 500-514.

Wolffe, R., Crowe, H.A., Evens, W., & McConnaughay. (2013). Portfolio as a teaching method: A capstone project to promote recognition of professional growth. *Journal of College Teaching & Learning, 10*(1) 1-5.

Zou, T.X.P., & Chan, B.Y.B. (2016). Developing professional identity through authentic learning experiences. In M. Davis & A. Goody (Eds.) Research Development in Higher Education: The Shape of Higher Education, 39, 383-391. Fremantle, WA, Australia, 4-7 July 2016.

Zubizarreta, J. (2009). *The learning portfolio: Reflective practice for improving student learning* (2nd ed.). San Francisco: Jossey-Bass.