Collaborative resource development for energy efficiency education

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Structured abstract

BACKGROUND
There is a growing volume of open source 'education material' on energy efficiency now available however the Australian government has identified a need to increase the use of such materials in undergraduate engineering education. Furthermore, there is a reported need to rapidly equip engineering graduates with the capabilities in conducting energy efficiency assessments, to improve energy performance across major sectors of the economy. In January 2013, building on several years of preparatory action-research initiatives, the former Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (DIICCSRTE) offered $600,000 to develop resources for energy efficiency related graduate attributes, targeting Engineers Australia college disciplines, accreditation requirements and opportunities to address such requirements.

PURPOSE
This paper discusses a $430,000 successful bid by a university consortium led by QUT and including RMIT, UA, UOW, and VU, to design and pilot several innovative, targeted open-source resources for curriculum renewal related to energy efficiency assessments, in Australian engineering programs (2013-2014), including 'flat-pack', 'media-bites', 'virtual reality' and 'deep dive' case study initiatives.

DESIGN/ METHOD
The paper draws on literature review and lessons learned by the consortium partners in resource development over the last several years to discuss methods for selecting key graduate attributes and providing targeted resources, supporting materials, and innovative delivery options to assist universities deliver knowledge and skills to develop such attributes. This includes strategic industry and key stakeholders engagement. The paper also discusses processes for piloting, validating, peer reviewing, and refining these resources using a rigorous and repeatable approach to engaging with academic and industry colleagues.

RESULTS
The paper provides an example of innovation in resource development through an engagement strategy that takes advantage of existing networks, initiatives, and funding arrangements, while informing program accreditation requirements, to produce a cost-effective plan for rapid integration of energy efficiency within education. By the conference, stakeholder workshops will be complete. Resources will be in the process of being drafted, building on findings from the stakeholder engagement workshops. Reporting on this project "in progress" provides a significant opportunity to share lessons learned and take on board feedback and input.

CONCLUSIONS
This paper provides a useful reference document for others considering significant resource development in a consortium approach, summarising benefits and challenges. The paper also provides a basis for documenting the second half of the project, which comprises piloting resources and producing a 'good practice guide' for energy efficiency related curriculum renewal.

KEYWORDS
Energy efficiency education, resources development, rapid curriculum renewal

Introduction

As part of the Australian Government's Clean Energy Future Plan, the Clean Energy and Other Skills Package includes four years of funding (from 2011/12 to 2014/15) to enable tradespeople and professionals in key industries develop the skills required to deliver clean energy services, products and advice to Australian communities and businesses. Energy efficiency (EE) is a key focus, widely recognised as the simplest and most cost-effective way to reduce Australia's greenhouse gas emissions and manage rising energy costs.

This Federal funding includes building the capability of higher education to deliver energy efficiency knowledge and skills to professionals. It addresses critical needs identified in several studies to date, to dramatically increase exposure to energy efficiency principles and application in undergraduate engineering education (Desha and Hargroves, 2009; RET, 2011a; RET, 2011b). Indeed, although there is a growing volume of 'education material' now available online in Australia (Office of Learning and Teaching, n.d.) and examples of energy efficiency related curriculum (for example The Natural Edge Project, 2007), the level of integration within curriculum is still *ad hoc* and fragmented, often champion-based with small audiences and often short-lived (Desha and Hargroves, 2014).

In late 2010, the Department of Resources, Energy and Tourism (RET) established the Energy Efficiency Advisory Group (EEAG) to provide guidance on a number of strategic initiatives being investigated by the department, to support an increase in energy efficiency knowledge and skill development in university engineering courses. Over the following two years this advisory group comprising around 15 academics worked on a number of projects (RET 2011a, RET 2011b, RET 2012) to address a terms of reference which included:

- Advice on, and input into, the development of guiding documents and education resources aimed at increasing the level of graduate knowledge and skills, particularly in industrial[1] applications.
- Facilitate the inclusion of energy efficiency content in relevant courses in Australian higher education institutions, as a priority area within the broader context of education for sustainability (EfS).
- Establish and grow a network of Australian higher education institutions interested in embedding energy efficiency content in relevant courses, and encourage an exchange of information and views on this process of curriculum renewal between network members.

In 2011, the EEAG observed an opportunity for the government to fund targeted energy efficiency resources for engineering education, through an action research oriented approach to curriculum renewal that could address previously identified barriers to curriculum renewal in Australian universities (Desha *et al*, 2007). In particular, the EEAG sought to address the issues of budget for curriculum renewal, flexible resources that target priority knowledge and skill areas, and accessibility of potential curriculum resources (i.e. online open access), to create urgently needed teaching and learning materials, resources and aids, that are 'course-ready' and suitable for immediate use. Furthermore, such resource development needed to build on previous investigations in this area and focus on priority engineering graduate attributes identified through workshops with Engineers Australia in 2012. The Federal government subsequently developed an unprecedented Request for Quote (RFQ) which valued consortium submissions for funding, the development and inclusion of professional networks as stakeholders, and rigorous piloting and evaluation of the resources to develop open-source online resources and supporting teaching guides.

Within this context, this paper discusses a project being funded under Element 3 of DIICCSRTE's Clean Energy Package, called the "Energy Efficiency Education Resources for

[1] The term industrial includes all large energy users (businesses using over 0.1 petajoules of energy per annum). This includes commercial building operators and commercial transport, and may soon include electricity generators.

Engineers" – EEERE – Project (June 2013 to November 2014). In particular, the paper discusses several project management innovations of the project that has responded to the RFQ, drawing on the consortium's collective experiences in collaborative projects to date. This includes an expansive consortium-based approach to developing open-source curriculum in a timely and collaborative manner, and concurrent pedagogical innovations embedded within the project. The paper begins with an overview of the consortium model used, and then the collaborative method for developing resources. It is hoped that these insights and opportunities with regard to consortium-based curriculum renewal will encourage discussion and further sharing about ways to foster such projects in future.

Engaging in a consortium approach to curriculum renewal

The aim of EEERE is to provide resources and supporting materials to assist the higher education sector, in particular engineering, industry, and built environment related courses, to rapidly equip graduates with the ability to conduct energy efficiency assessments and improve energy performance across major sectors of the Australian economy. The resultant consortium governance structure is shown in Figure 1. Given the short time frame of the project of just 18 months, the consortium was compiled to create direct reporting requirements, minimise contractual paperwork, short-circuit timeframes for coming to terms with project requirements, and to involve as many institutions as practical across the spectrum of cultural and operational contexts. Such consortium considerations drew primarily on personal experiences of the individual members, with insights also gleaned from several relevant management articles including Carayannis *et al* (2000) and Miotti *et al* (2003). The consortium partnership brings together six universities including RMIT, UA, UOW, VU and subsequently LaTrobe University, covering half of the states and territories (Queensland, South Australia, NSW, and Victoria).

The consortium formation also involved a number of Australia's leading energy efficiency educators who played lead roles in previous federally funded energy efficiency capacity building investigations, who lead the field in many areas, and who are part of key national advisory structures. It also meant collaborating with key supporters and organisations active in this area that could reach out to members and partner organisations with regard to contributing to and reviewing resources. This included Engineers Australia, the Australian Council of Engineering Deans, the Australasian Association for Engineering Education, the NSW Office of Environment and Heritage, the Australian Power Institute, and the Australian Sustainable Built Environment Council.

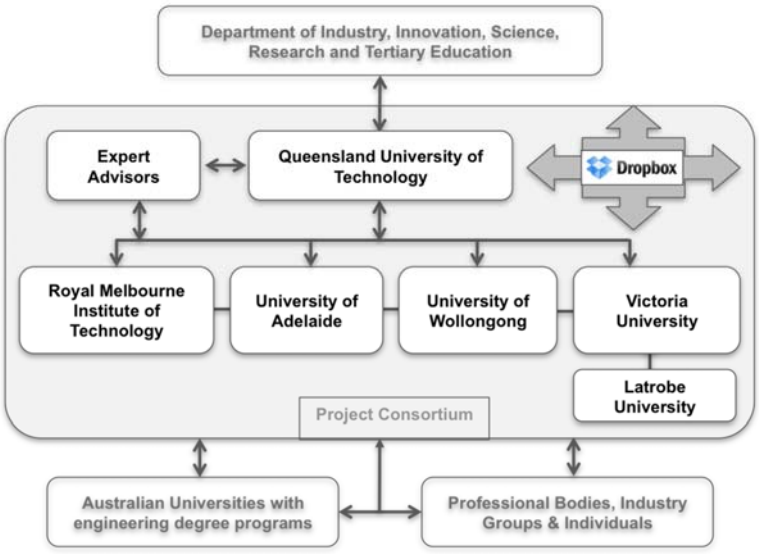

Figure 1. EEERE project governance structure

Collaborative methods for developing resources

Here we discuss the consortium's process and pedagogical considerations in scoping the project, and challenges with this approach. In summary, the project objectives were to: develop targeted resources and supporting materials to assist Australian Universities develop priority attributes in graduates related to energy efficiency assessments; pilot, validate or peer review, and refine the drafted resources as appropriate; and develop an engagement strategy that takes advantage of existing networks, initiatives, and funding arrangements and program accreditation requirements, for rapid integration of energy efficiency as a priority consideration within engineering education.

Several key challenges with this scope and an 18-month timeframe were identified during the proposal preparation phase, which carried risks regarding timeframe and budget, including:

- The number of universities involved in collaborative work tasks with associated contract negotiation and administrative workload, and the potential for large delays in start-dates.
- The number of potential key stakeholders involved with associated time for interactions and follow-up, and the potential for delays due to consultation.
- The potential for a federal government election mid-way through the project affecting stakeholder involvement and project focus (particularly associated with the carbon tax), and the potential for delays due to additional consultation.

Figure 2 summarises the four-staged project work plan, referred to in the following paragraphs.

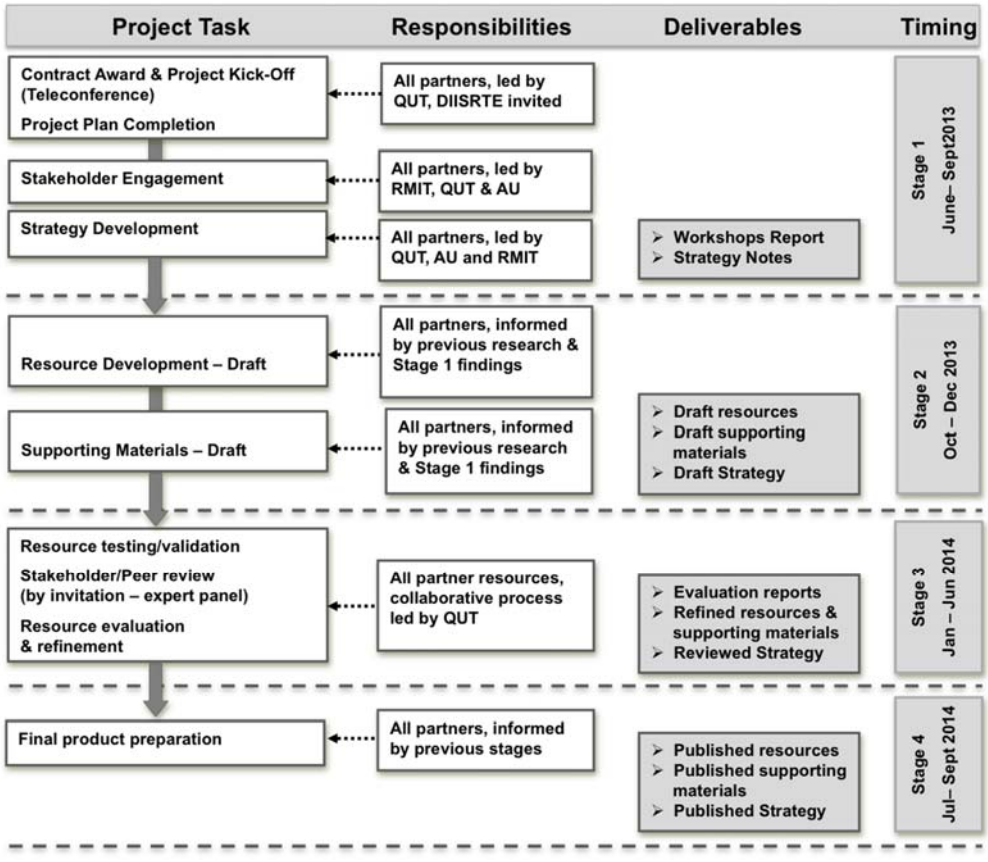

Figure 2. Project tasks, responsibilities, deliverables and timing

Process considerations

Considering the potential challenges outlined above, consortium members chose to front-end-load the curriculum development process, to ensure clarity around scope and focus for stakeholders and consortium partners, and to circumvent delays in piloting the resources in Semester 1 2014. This included accurately determining the graduate attributes to be targeted, component knowledge and skill areas within the first three months of the project timeline through consultation with industry and project stakeholders. A major administrative challenge arose in the payment of consortium partners and their research assistants to be involved in this part of the project, due to the 2-month timeframe for contract negotiations. In this instance, the lead university – Queensland University of Technology – took on responsibility for delivering the initial consultation component of the project, collaborating with RMIT personnel who had a major role in the consultation phase, to employ a research assistant who could deliver on both institutions' objectives. Such flexibility in staff resourcing and having the major initial tasks covered by the lead university has enabled the project to keep to its original timeframes despite consortium contracts being signed several months after the head-contract.

Considering the extensive consultation already undertaken in 2012 by RET (RET, 2012) and the need to check-in on industry perspectives in a way that did not appear to be repeating previous research, the consortium chose an invited workshop approach with very clear objectives. In this approach, individuals were contacted using the consortium's exsiting network of industry, government and academic colleagues who were already familiar with the context of energy efficiency education in engineering, an in particular the need for developing capabilities in energy efficiency assessments. Subsequently the contracted obligation of 8-12 participants in each of three workshops (Brisbane, Melbourne, Sydney) were met.

Pedagogical considerations

Considering previous research and recommendations into what is required for building capacity in energy efficiency assessments, this project focuses on Graduate Attributes for each of the Engineers Australia disciplines, providing targeted information (existing and new) to assist engineering educators to deliver such attributes to students. Considering the potential for scope creep, the consortium chose to focus on critically important graduate attributes in the proposed resource development, across all disciplines identified in the 2012 College Briefing Note produced for RET (RET, 2012), including Biomedical, Chemical, Civil, Electrical, Environmental, ITEE, Mechanical, Structural Engineering, along with Mining and Metallurgy. The project also intends to guide accreditors of engineering programs on the process to identify engineering education for energy efficiency that is mapped to the identified graduate attributes.

In addition to considering who to target with the resources, the consortium chose an array of pedagogical approaches to address how the resources should be packaged. Following check-in with key stakeholders in the first stage of the project, this comprised:

- ***Flat-pack modules*** (University of Adelaide), comprising 10 word and pdf enabled documents on various aspects of energy efficiency assessments, addressing key priorities previously highlighted during the 2012 industry consultation by nine major engineering disciplines, and an introductory module applicable to all of the disciplines.
- ***Multi-media packages*** (Queensland University of Technology), comprising 10 three-minute YouTube style multi-media, targeting the same audience as the flat-pack modules and designed to complement the modules in scope and context.
- ***Deep dive case studies*** (University of Wollongong), comprising calculation-based explorations of a commercial building and an industrial facility, addressing key technical competency needs previously identified during the 2012 consultation.
- ***Virtual reality experience*** (Victoria University and Latrobe University), comprising an avatar-style tutorial experience within a commercial/ industrial facility, addressing the potential for assessment considerations that can lead to significant improvements.

A stakeholder engagement report was also designed into the project, to provide stakeholders and the federal government with a suite of recommendations for dissemination and take-up of the project's resources.

Content considerations

Further to the *Energy Efficiency Opportunities* program context (REF) and drawing on previous research, the project was designed to address both *enabling* and *technical* knowledge and skills, through graduate attributes related to *identifying*, *evaluating* and *implementing* opportunities. With regard to enabling knowledge and skills, as summarised in Table 1 and confirmed during initial stakeholder engagement, this includes a focus on whole system thinking, understanding the business case, and communicating with other disciplines and management regarding opportunities and their implementation.

With regard to technical knowledge and skills, considering critical roles that engineers play in conducting assessments for energy efficiency improvements, the focus of the resources in are as follows, creating a foundation for other areas to be targeted in future.

Industry Sectors: With a growth rate of energy consumption second only to the mining sector, in 2012 transport held nearly 40% of the share of energy demand in Australia, followed closely by manufacturing and construction (some 28%), and commercial and residential buildings (some 20%). Within the mining industry, through Mining Education Australia there has been significant work to develop resources to engage students in education for sustainable development. In contrast, the transport, manufacturing, construction, and buildings sectors have experienced highly ad hoc and fragmented efforts to build capacity in improving energy efficiency, with many opportunities to improve performance through the federal government's focus on energy efficiency assessments.

Hence, preference will be given to the following high priority industry sectors, to target the areas of high energy-demand and low levels of current capacity building for *energy efficiency assessments*, in *undergraduate engineering education*, aligning with graduate attribute selected and the strength and capacity within the consortium members. This includes:

⇒ ***Manufacturing/ Construction/ Commercial Buildings****,* for which there are extensive education materials available that will be used as a foundation to build knowledge and skills around selected graduate attributes and for which the consortium is also able to draw on industry partner expertise.

⇒ ***Heavy industry****,* for which the consortium and national experts in energy efficiency will distil key aspects of this industry to deliver critical energy efficiency related teaching and learning opportunities for undergraduate engineering.

Technologies: The resources and supporting materials will select a mixture of technologies suitable to demonstrate to each discipline the context and application of each graduate attribute selected. Hence technologies will be selected across each of engineering fields:

⇒ ***Combustion engines, turbines, boilers, or electric drive systems****,* due to the large potential for energy savings and the proliferation of such technology across all sectors.

⇒ ***Ventilation systems, fans and blowers, motors, lighting systems, and HVAC****,* due to the prolific opportunities across all sectors including manufacturing, and buildings, ability for students to relate to such technology and learning and teaching potential.

⇒ ***Information and Communications Technologies****,* due to the growing opportunity to reduce the energy consumption of such technologies and to use such technologies to reduce the energy consumption of a number of sectors.

⇒ ***Industrial and Commercial Industry Buildings and Envelopes****:* due to the significant potential for energy efficiency improvements, the visual appeal for students and subsequent learning and teaching potential of interactive 3D learning programs.

⇒ ***Civil construction associated with roads and transport infrastructure,*** due to the need to respond to resource price increases and reductions in raw material availability.

Conclusions

This consortium-based project has been designed to deliver a suite of resources that goes beyond traditional information-laden content development, drawing on the expertise of individual consortium members and using a collaborative approach to design, evaluation and fine-tuning the resources. In this way, the resources can target a range of graduate attributes identified in consultation with Engineers Australia, to create an empowering platform for students to consider energy efficiency problems within the context of their own discipline.

This approach focuses on addressing key priorities identified in the Briefing Note published from the 2012 industry consultation project, including resources that align with Engineers Australia Stage 1 Competency Standard elements. In this way it is hoped that the project creates incentive for academics to use the resources as a straightforward way to demonstrate suitable programs during accreditation review. Pending future funding, additional resources could be developed to address other priorities in the Briefing Note.

Key strengths of a consortium-based curriculum renewal approach include:

- Collaboration across culturally and geographically different institutions, where drawing on each institution's strengths provides a robust set of resources that are readily accessible across the cultural landscape of higher education.
- Strengthening and expansion of the existing network of academics committed to capacity building for energy efficiency in Australia
- Strengthening academic-industry communication at the level of an engaged community of practice, through actively involving a number of key industry and professional body stakeholders in developing and delivering the proposed resources.
- Connecting open-source online materials to specific graduate attributes that are already freely available and online, enhancing the learning opportunities for undergraduate engineering education through focused energy efficiency resources.

Key challenges for consortium-based curriculum renewal approach include:

- Long lead times for contract negotiation and signing. In this project, there was significant benefit in keeping the initial tasks (i.e. first three months of the project) managed by the lead university, in this case the Queensland University of Technology. This allowed the sub-contracting process to proceed in parallel with the first phase of the project, overcoming the logistical barrier and time constraints associated with contract negotiation project set up at each of the consortium universities.
- The need for quite specific tender specifications at the level of institutional tasks to readily create subcontractor agreements between the lead university and consortium partners. In this project, consortium partners developed a detailed project plan at the proposal stage, to ensure that this level of specificity was available for the subcontracts to be prepared.
- Overcoming traditional curriculum development goals (university-specific, not-transferable). In this project consortium partners spent some time during the proposal preparation phase considering innovative ways to address the identified priority knowledge and skill areas. Innovation pathways were uncovered by looking for exemplar education initiatives in each institution, then considering how these successes could be built on within this project.

Table 1. Matrix of Project Resource Objectives (by Consortium Partner)

Partner	Project Element	Resource Focus	Industry Sectors	Technologies and processes	Engineering Sub-Disciplines^	Main K&S Areas (key words of focus)
QUT	⇒ Resources, Supporting Materials ⇒ Engagement Strategy	Multi-Media Packages Flat-Pack Modules	Manufacturing (contextual to the disciplines being considered) Commercial transport (road construction) Commercial buildings	Contextual to the disciplines being considered, including for example: Boiler systems, Dryers, Pumping systems, HVAC systems, ICT, Aggregates, pavements, and concretes.	Addressing the nine major disciplines identified in the 2012 Engineering Briefing Note, expanding on Section 2 of the document for each discipline.	***Information, data and analysis*** ⇒ EE Principles, units of measure & limitations ⇒ Financial calculations and implications ⇒ Whole of life analysis ⇒ Whole system design ⇒ Individual and team work ***Opportunity identification and evaluation*** ⇒ Big-picture context ⇒ Whole of life evaluation ⇒ Financial evaluation ⇒ Communication (verbal and non-verbal)
UA	⇒ Resources, Supporting Materials ⇒ Engagement Strategy	Flat-Pack Modules				
UOW	⇒ Resources ⇒ Supporting Materials	Deep Dive Case Studies	Commercial buildings, Heavy industry	Electrical distribution, ventilation systems, fans and blowers, motors, lighting systems, and HVAC	**Primary:** ⇒ Mechanical ⇒ Electrical ⇒ Civil **Secondary:** ⇒ ITEE ⇒ Environmental	
VU Latrobe	⇒ Resources ⇒ Supporting Materials	Virtual Reality Experience*	Industrial and commercial industries	Building design and retrofit, and effects of industrial and commercial heat loads		
RMIT	⇒ Stakeholder Engagement ⇒ Engagement Strategy	Stakeholder Engagement Report *(to inform resources & supporting materials)*	All of the above	All of the above	All of the above	

* Three-dimensional interactive energy efficiency education platform.

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Acknowledgements

The authors would like to thank all members of the EEERE Consortium, who have provided commentary and input into the ideas and processes discussed in this paper. The authors also thank the 40 workshop participants (Brisbane, Sydney and Melbourne) including stakeholder partners, college members, industry and academic colleagues, who provided their time and ideas so generously.

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