34th Australasian Association for Engineering Education Conference
3 - 6 December 2023 – Gold Coast, QLD

Using Program Logic Models to Evaluate Curriculum Design Decisions

Alexander A Kist[a]; Justine Baillie[b], and Catherine Hills[a].
School of Engineering, University of Southern Queensland, Toowoomba, Australia[a];
School of Agriculture and Environmental Science, University of Southern Queensland, Toowoomba, Australia[b]
Corresponding Author Email: kist@ieee.org

ABSTRACT

CONTEXT

Engineering programs undergo curriculum renewal to remain relevant and fit for purpose. There are many driving factors for updates, including workplace and sector changes. Many of these drivers were accelerated by the global pandemic. The ongoing disruptions caused by digital technology to businesses and society also have an impact, both for how engineering is taught and what needs to be covered in the curriculum. The required shift in engineering education has been qualified in a scoping study commissioned by the Australian Council of Engineering Deans.

PURPOSE

Many design decisions are inevitably tacit, not documented in detail and not directly visible outside the program development team when undertaking a complex curriculum renewal project. This makes it difficult to evaluate the implementation. In the context of social interventions, evaluations are the norm. Examples of evaluation frameworks include the theory of change and logic models. This leads to the research question for this project of whether an extended *program logic model* can be used in a meaningful way to capture the interdependencies of factors that impact curriculum design and evaluate the impact of the curriculum innovations on the intended outcomes. In a practical sense, the main aim of the work is to make the design decisions visible, systematic and their impact measurable.

APPROACH

Program logic models are normally used in the context of evaluating interventions and programs in a social and health context. Crosthwaite et al. (2009) have argued that these approaches can also be applied to educational interventions. A program logic model makes otherwise implicit links between activities, outputs, and immediate and long-term impact explicit through a schematic representation. Using the curriculum renewal project as a case study, this paper demonstrates how an extended program logic model can be used in the context of a large-scale curriculum re-design project akin to a new program development.

OUTCOMES AND CONCLUSIONS

The extended program logic model provides a clear line of sight between program building blocks and features and short-, mid-, and long-term outcomes. It outlines evaluation strategies for aspects of the program and articulates possible evidence that can demonstrate that the interventions have the anticipated impact. The proposed model can also serve as a tool to communicate the reasoning behind interventions to stakeholders.

KEYWORDS

Curriculum renewal, program logic model, evaluation.

Introduction

Continuing advances in engineering, technological change, shifting expectations by society and changing industry needs require ongoing curriculum change in engineering education. To ensure that graduates are well-equipped to thrive in their chosen professional careers, educational content, learning support, and teaching methods need to remain current and relevant. Curriculum change might be driven by ongoing quality assurance processes that use data to ensure that programs deliver intended learning outcomes and meet other quality standards (Bullen, 2010) or that changes are initiated for strategic reasons such as large-scale and new program developments. Step changes often occur in response to calls to action as outcomes of reviews (Crosthwaite, 2021). Calls for renewals and challenges are nothing new. For example, Wormley (2004) citing Splitt (2003) summarises the drivers at the time as

> *…including the rapid technological advances in the engineering disciplines, the necessity to attract strong and diverse groups into the engineering profession and the realization that engineering is practiced in a global environment (Wormley, 2004, p. 329).*

These were linked to skills seen as preparing "engineers generally for the profession, such as communication skills, teamwork, lifelong learning and ethics" (Wormley, 2004). These changes in focus manifested in changes to the accreditation requirements of accreditation bodies such as Engineers Australia and ABET.

We are again at an inflection point, with factors that will drive and, in some cases, force change. This includes changes to the workplace and the sector that were accelerated by the pandemic, but also the ongoing disruptions caused by digital technology to business and society. These changes are also happening in the engineering profession and were qualified in a scoping study commissioned by the Australian Council of Engineering Deans (ACED) that explored "the knowledge, skills and attributes of professional engineers required to meet anticipated changes in the nature of engineering work in Australia in the year 2035" (Crosthwaite, 2019).

The study identified that a step change in engineering education is required to deliver graduates needed and valued by the industry. It emphasises a move from "I" shaped graduates with a strong technical focus to "T" shaped graduates with technical competencies complemented with professional skills and expertise.

Another current focus is the inclusion of sustainability (Desha, Rowe, & Hargreaves, 2019) and the United Nations Sustainable Development Goals (United Nations 2015). This shift is also evident in the revision of the International Engineering Alliance (IEA) to its Graduate Attributes and Professional Competencies (GAPC) international benchmark. These changes will flow through to the Engineers Australia graduate attributes in due course. Other drivers for change in Australia include the increasing shortage of Professional Engineers and changing student expectations regarding educational programs.

As educational programs respond to these drivers, purposeful change is required. McLeod and Steinert (2015) make a convincing case for evaluating curriculum renewal in the context of medical education that is directly transferable to other disciplines.

> *Ongoing curriculum renewal should mandate that we evaluate the impact of any change we introduce. Not only is such an approach beneficial to learners and educators, it is also an important part of our mandate to be socially accountable for the changes made and for monitoring the outcomes of the changes (McLeod & Steinert, 2015, p. 236).*

Educational interventions have complex interdependencies and simple pre/post-tests do not account for the complexity of the situation. The four-level evaluation model of Kirkpatrick (1994) is often cited as an example and used in this context.

Proceedings of AAEE 2023 Griffith University, Gold Coast, Qld, Australia. Copyright © Alexander A Kist, Justine Baillie and Catherine Hills, 2023.

Specifically looking at curriculum renewal, many models have been proposed (Nouraey, Al-Badi, Riasati, & Maata, 2020). Models for program evaluation typically have the objective of determining whether a program meets predetermined objectives. In this context, the term program can be misleading as it can refer to both a broad program of intervention as well as a formal program (or course) of study such as a Bachelor of Engineering.

Many curriculum and educational program design decisions are inevitably tacit, not documented in detail and often not directly visible outside the program development team. This is particularly true when undertaking a complex curriculum renewal project. This makes it difficult to evaluate the implementation of the facets of the educational program and leads to the research question of whether an extended program logic model can be used in a meaningful way to capture the interdependencies of factors that impact curriculum design and provide a blueprint to evaluate the impact of the curriculum innovations on the intended outcomes. In a practical sense, the main aim of the work discussed in this paper is to make the design decisions visible, systematic and their impact measurable.

The remainder of the paper is organised as follows. The next section discusses the overall framework, followed by a section that explains the methodology in more detail. In contrast to standard logic models, this section discusses a novel, compartmentalised approach using various lenses. In the second part of the paper, a significant course of study renewal project is used as a case study to demonstrate how the extended model operates. In addition, the discussion provides some insight into the educational program suite. To illustrate the approach, two examples are covered, one covering the sense of belonging and the other accounting for the United Nations Sustainable Development Goals. The paper concludes with observations.

Framework

Program evaluations are standard practice in the context of social science to establish the impact of interventions in public health and welfare, for example. Using systematically gathered and analysed data helps to assess effectiveness, guide decision making and ensure accountability. It also helps to understand complex issues, facilitate stakeholder conversations, and focus on impacts and how those can be measured. Program theory in the development and evaluation of programs is an active field of theoretical research (Savaya & Waysman, 2005).

All these aspects suggest the program evaluation frameworks lend themselves to measuring the impact of curriculum and delivery change in the context of higher education. One example is *program logic models* that make implicit links between activities, outputs, and immediate and long-term impact explicit through a schematic representation (University of Wisconsin-Madison, 2023). While normally used in the context of evaluating interventions and programs in the social and health fields, they have also been used to evaluate educational programs and interventions (Brodie, Bullen, & Jolly, 2011; Crosthwaite, Jolly, & Brown, 2009).

As *program logic models* provide a visual representation of the resources, activities, goals, outputs, and outcomes (illustrating how the impact is achieved), they provide a clear line of sight between program building blocks and features and short-, mid, and long-term outcomes. This simplifies the evaluation of the program and provides evidence that the interventions have the anticipated impact. The models also serve as a tool to communicate the reasoning behind interventions to stakeholders.

Methodology – Extended Program Logic Models

The general use of *program logic models* is well documented (e.g.University of Wisconsin-Madison, 2023). Key components of the program, including goals, resources, activities and actors, short, medium, and long-term effects are recorded. The relationships between these components are articulated, illustrating how activities lead to observable outcomes and, ultimately, how the goals are achieved.

 Copyright © Alexander A Kist, Justine Baillie and Catherine Hills, 2023.

This is captured in a visual representation (a diagram) that maps the relationships and helps to develop a common understanding of the underlying logic and assumptions. The representation is used to engage stakeholders to ensure that the logic model accurately reflects context, complexity, and intended impact. Logic models are not meant to be set in stone. As things change, they can be reviewed and refined.

Typically, logic models capture the complete program in one diagram. However, when looking at a significant curriculum project or at a new program (or course) of study, one single diagram becomes intractable. Instead, we proposed to use different instances of the model to capture specific aspects and their impacts. Using this compartmentalised approach keeps the individual models manageable. It allows individuals to engage with part of the project without having to understand every aspect in minute detail. The first-year team, for example, is able to look at only aspects it can control without losing the overall interconnectedness and multifaceted view of the program. This approach allows the team to compartmentalise the program evaluation while maintaining an overall systems view.

The inputs and the situation in the broader sense remain the same, as do some of the outputs. However, their impact and how the impact is measured can differ between instances. In the next section, we discuss a specific case study that illustrates the approach with a practical example.

Case Study

The *Past Excellence New Success in Engineering Education (PENS-E^2)*, now *Engineering Better Futures*, is a major curriculum renewal project of a suit of undergraduate Engineering programs, namely the 2-year Associate Degree of Engineering, the 3-year Bachelor of Engineering Technology and the 4-year Bachelor of Engineering Honours. The project has clearly articulated goals accounting for the recommendations of ACED's Engineering Futures 2035 report (Crosthwaite, 2021) and an external review, among other constraints. It has a well-established governance structure, and the constructively aligned program suite has been designed to achieve a broad range of goals. The project goals for the curriculum and delivery renewal include:

- Financially viable programs
- T-shaped graduates (greater emphasis on human-focused, big picture systems thinking, problem definition, problem finding, problem-solving, creativity and innovation, digital intelligence, collaboration and communication, adaptability, and resilience)
- Quality assurance for program-level competencies
- Multiple pathways with personalisation to allow students to fast track as well as to address gaps/weaknesses
- Different approaches for different cohorts (school leavers, change of career, working in industry).
- Best in-sector student experience.
- Staff who are competent, engaged and invested in delivering a state-of-the-art engineering education.

The overall program has been approved by the academic board and is in the implementation phase for delivery in 2024. The program suite has five main building blocks. Micro learning modules that are self-directed, competency-based, pass-/fail and are supported through learning communities. Project-based courses that apply the knowledge and skills to authentic engineering projects and develop both technical and transferable skills. The professional practice and personal development stream that focusses on onboarding, identifying strengths and opportunities for growth, goal setting and planning, professional development, and placements. Learning communities are run synchronously and asynchronously and offer students opportunities to engage with each other and academics. The last building block is free electives that allows students to address gaps and extend their knowledge.

Undertaking a major curriculum and delivery renewal program makes it essential that sound evaluation occurs to capture and document how the program is achieving its set goals. Given the

 Copyright © Alexander A Kist, Justine Baillie and Catherine Hills, 2023.

complexity of the project and the multitude of interventions that are embedded in the program redesign, establishing an evaluation strategy is not straightforward. Factors are multifaceted and interdependent. Therefore, an extended *program logic model* approach is taken as it provides a framework and a way of thinking to introduce accountability for results.

A logic model can be applied with diverse lenses and scopes. In the example discussed in this paper, we use the approach to identify measurable outcomes and impacts that relate to very specific objectives of the overall program renewal. Generic constraints such as accreditation requirements and university policy and procedures are generally black and white, and as such, there is little value in tracking how these are met over time. How these constraints are met is well documented, and for the purpose of the logic models, these are captured under assumptions.

One of the broad project goals is to offer the best student experience, a more specific objective flowing on from this goal is to strengthen the sense of belonging. Another example is the goal to support the development of well-rounded, T-shaped graduates. Here the specific objective is to empower students to account for the UN SDGs in their practice.

We can take a similar approach to look at other, more tangible aspects of the program delivery, such as financially viable programs. Other focus area for evaluation will account for creativity, big picture thinking, systems and integration, digital intelligence, emotional intelligence, resilience, personalisation, student experience, problem finding/framing/solving abilities.

To demonstrate how the model works, we unpack two specific aspects in this paper: analysing and evaluating sustainable development impacts in the context of the United Nations Sustainable Development Goals and fostering a sense of belonging as students transition to university. We have selected these less tangible aspects as it is not immediately obvious how the success in these areas can be measured and they therefore provide richer, transferable examples.

Figure 1 and Figure 2 show the logic models for both lenses. Key inputs in both cases are staff resources that are required to develop and deliver the content and support the student learning. Assumptions are that the program suite has been designed to meet professional accreditation and institutional policy requirements. Below we discuss the context for both lenses in more detail.

Sense of Belonging

The sense of belonging captures the connection, emotional attachment or identification with the academic environment, the discipline area, and the university. As students transition into university study, they may find it challenging to feel a part of these new, often diverse, communities. This might be more pronounced for mature age, online students or students who identify with other equity groups. Belonging touches on relationships with peers, academic culture, and instructional culture. The sense of belonging impacts on engagement, motivation, and academic success. In our context, the sense of belonging also encompasses the profession.

A sense of belonging has been the centre of several frameworks for university success. Lizzio (2006) measured connectedness, being the connections between a student and their peers, staff, and institution. Kift, Nelson, and Clarke (2010) identify one of four key first year strategies as “Intentionally fostering a sense of belonging” in their Transition Pedagogy. A sense of connection to the people and places around a student assist with success and retention, as well as economic benefits for educational institutions (Kift et al., 2010). In the context of our programs, we have identified transition as being particularly important (Hills et al., 2023).

Figure 1 shows the Logic Model that covers this aspect. There are several building blocks in the curriculum that foster the sense of belonging including an orientation for credit course, learning communities and a *professional practice and personal development course* stream. Key activities contributing to the development of a sense of belonging include social activities, exposure to the profession and support to plan their personal learning journey.

Accounting for the United Nations Sustainable Development Goals

The United Nations Sustainable Development Goals or SDGs are a “shared blueprint for peace and prosperity for people and the planet, now and into the future” (United Nations 2015). The SDGs recognise that social equity, economic growth, and environmental considerations are interdependent and essential for achieving a sustainable future.

Engineers play a pivotal role both as technological pioneers but also as enablers of sustainable development and environmental stewardship. Scholars have advocated for systematic change and embedding sustainability in engineering programs for well over twenty years “to produce engineers who can make a positive difference – for people, plant and prosperity” (Desha et al., 2019).

In the context of this engineering program suite, the aim is to empower the students to get to a point where UN SDGs are part of their practice framework independent of discipline or where they work. Figure 2 depicts the logic model with the lens of the UN SDGs. Key activities that support this goal included learning modules that cover foundational knowledge on humanitarian engineering, UN SDGs and the human side of engineering.

This knowledge is applied in a project-based course that feature the Engineers without borders challenge. Other projects in the curriculum, while not specifically focusing on UN SDGs will continue to make a connection through either specific learning outcomes and related assessment rubric criteria or through self-reflection that are captured in the portfolio. The final data points include how effective students have addressed the UN SDGs in their honours project and how well they are covered in their personal graduate statement.

Observation

As the two examples show, the extended models work well for capturing measurable outcomes. Formulating the situation statement was the starting point as it defines the focus of the lens for a particular model. Conversations around these statements have allowed the team to establish a common understanding of the scope and coverage of a lens. Inputs and outputs are similar for both lenses as they cover the same curriculum renewal. The most interesting aspects of the logic model are the outcomes and impacts as these capture tangible indicators that need to be visible now to lead to long-term impact. When developing the models, it has been helpful to ask the question of what behaviour or artifacts need to be visible at a particular point in the program that demonstrate that students are on the right track. This is particular useful for less tangible measures.

Given the multifaceted design of an educational program, it may not be possible to establish a direct causal relationship between outputs and outcomes. However, in a practical sense, this is a secondary consideration if the logic models clearly articulate mechanisms to establish whether the intended outcomes are being achieved.

Conclusions

Using an extended program logic model framework has been productive in supporting conversations around evaluation. It has provided an approach to unpack how less tractable aspects can be evaluated in a meaningful way. Developing the models has shown that short-term outcomes in our context are often about creating several opportunities for students through activities and touchpoints. For example, offering students meaningful opportunities to engage with each other as a short-term goal has meant that effectively working in groups became a mid-term outcome. While the work has discussed the case study of a major project, the primary focus was to unpack the use of extended logic models for large-scale evaluations. The case study has clearly shown that extended logic models provide a viable framework to plan the evaluation of new educational programs or large-scale curriculum renewal projects. Future work will evaluate the value of the models in conversations with stakeholders and the accreditation panel.

Proceedings of AAEE 2023 Griffith University, Gold Coast, Qld, Australia. Copyright © Alexander A Kist, Justine Baillie and Catherine Hills, 2023.

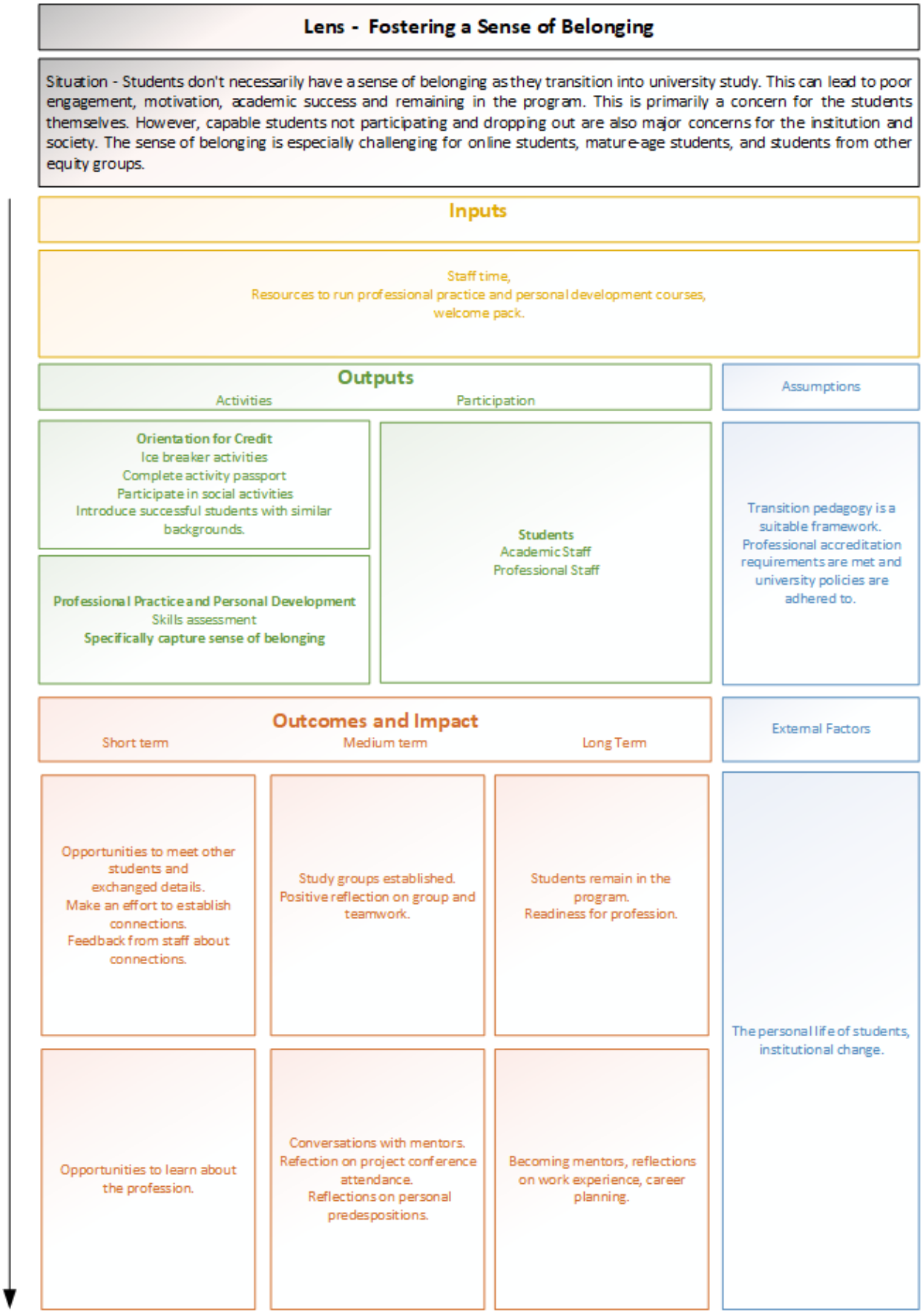

Figure 1: Logic model focussing on fostering a sense of belonging.

Proceedings of AAEE 2023 Griffith University, Gold Coast, Qld, Australia. Copyright © Alexander A Kist, Justine Baillie and Catherine Hills, 2023.

Figure 2: Logic model focussing on accounting for UN SDGs.

Proceedings of AAEE 2023 Griffith University, Gold Coast, Qld, Australia. Copyright © Alexander A Kist, Justine Baillie and Catherine Hills, 2023.

References

Brodie, L., Bullen, F., & Jolly, L. (2011, 12-15 Oct. 2011). *Effective evaluation strategies to meet global accreditation requirements.* Paper presented at the 2011 Frontiers in Education Conference (FIE).

Bullen, F. (2010). *Evaluation - the driver of the engineering education machine*. Paper presented at the 21st Annual Conference for the Australasian Association of Engineering Education (AAEE 2010), Sydney, Australia.

Crosthwaite, C. (2019). Engineering Futures 2035: A scoping study. *Australian Council of Engineering Deans, Report*.

Crosthwaite, C. (2021). Engineering Futures 2035 Engineering Education Programs, Priorities & Pedagogies. *Australian Council of Engineering Deans, Report*.

Crosthwaite, C., Jolly, L., & Brown, L. (2009). A program logic approach to evaluating educational innovations. *2009 Research in Engineering Education Symposium, REES 2009*.

Desha, C., Rowe, D., & Hargreaves, D. (2019). A review of progress and opportunities to foster development of sustainability-related competencies in engineering education. *Australasian Journal of Engineering Education, 24*(2), 61-73. doi:10.1080/22054952.2019.1696652

Hills, C., McAlister, C., Kist, A. A., Bailie, J., Quince, Z., & Seligmann, H. (2023). *Pass Go and Collect $200 - Orientation for Credit*. Paper presented at the 34th Australasian Association of Engineering Education Conference (AAEE 2023), Gold Coast, QLD.

Kift, S., Nelson, K., & Clarke, J. (2010). Transition pedagogy: A third generation approach to FYE-A case study of policy and practice for the higher education sector. *Student Success, 1*(1), 1-20.

Kirkpatrick, D. L. (1994). Evaluating Training Programs. The Four Levels. Berrett-Koehler Organizational Performance Series.

Lizzio, A. (2006). Designing an orientation and transition strategy for commencing students: Applying the five senses model. *Griffith University: First Year Experience Project*, 1-11.

McLeod, P., & Steinert, Y. (2015). Twelve tips for curriculum renewal. *Med Teach, 37*(3), 232-238. doi:10.3109/0142159x.2014.932898

Nouraey, P., Al-Badi, A., Riasati, M. J., & Maata, R. L. (2020). Educational program and curriculum evaluation models: a mini systematic review of the recent trends. *Universal J Educ Res, 8*(9), 4048-4055.

Savaya, R., & Waysman, M. (2005). The Logic Model. *Administration in Social Work, 29*(2), 85-103. doi:10.1300/J147v29n02_06

Splitt, F. G. (2003). Engineering education reform: A trilogy. *International Engineering Consortium*, 8-12.

United Nations (2015). Transforming our world: the 2030 Agenda for Sustainable Development. *UN Doc. A/RES/70/1 (September 25, 2015)*.

University of Wisconsin-Madison. (2023). Enhancing program performance with logic models. Retrieved 12/10/2023 from https://logicmodel.extension.wisc.edu/.

Wormley, D. N. (2004). Challenges in curriculum renewal. *International Journal of Engineering Education, 20*(3), 329-332.

Copyright statement

Copyright © 2023 Alexander A Kist, Justine Baillie and Catherine Hills: The authors assign to the Australasian Association for Engineering Education (AAEE) and educational non-profit institutions a non-exclusive licence to use this document for personal use and in courses of instruction provided that the article is used in full and this copyright statement is reproduced. The authors also grant a non-exclusive licence to AAEE to publish this document in full on the World Wide Web (prime sites and mirrors), on Memory Sticks, and in printed form within the AAEE 2023 proceedings. Any other usage is prohibited without the express permission of the authors.