A Review of Engineering Capstone Design Accreditation Criteria under the Washington Accord

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ABSTRACT

CONTEXT

Capstone (final year) design projects are an integral part of engineering programs. Typically, they develop and showcase graduate-level competencies in applying engineering tools and techniques to design solutions for problems. The Washington Accord outlines specific attributes in design. However, the implementation of capstone design varies across member countries of the Washington Accord, with their accreditation criteria specifying different approaches to incorporating design in engineering programs.

PURPOSE

This review compares design-related accreditation criteria across all Washington Accord member countries. Understanding common accreditation criteria will enable further research into leading practices in engineering capstone design projects.

APPROACH

Publicly available accreditation procedures, handbooks, guidance notes, criteria, program outcomes, competency standards and self-study reports from the 25 signatory counties of the Washington Accord were reviewed in line with the following focus areas:

- Definitions of Engineering Design
- Requirements for program structures to incorporate design
- Specifications for capstone projects

OUTCOMES

Local accreditation schemes interpret and apply design-related criteria differently. However, they must remain aligned with the Washington Accord. This review found that almost all Washington Accord member countries require a significant culminating design project. Very few countries specified how design should be scaffolded throughout the course, leaving a notable gap in program design specifications in the middle years. Definitions of Engineering Design are well developed and are continuously improving with additional context.

CONCLUSIONS

There may be several different ways of successfully designing an engineering program to incorporate capstone design projects to meet the expectations of accrediting bodies, students and industry. Future work will identify current and leading practices in engineering capstone design in Australia.

KEYWORDS

Design, capstone, accreditation

Introduction

Engineering design, regarded as an essential activity of engineering practice, is steeped in tradition and moulded by geographical and political context. We assume a common understanding of engineering design. However, in this author's experience, if you ask academics what they mean by engineering design, they will give you a different response based on their discipline, the country in which they studied, when they graduated, their industry experience, and the subjects they teach.

The Engineering Futures 2035 report to ACED highlights an opportunity for a stronger focus on multidisciplinary and human-centred engineering design in Australian professional engineering programs, particularly as a way to engage better with industry and professional practice (Lee et al., 2022).

In order to discover leading practices in engineering capstone design, it is helpful to first define what we mean by capstone design. Accreditation criteria are one useful way to compare and contrast the boundaries of capstone design in a global context. Hadgraft (2017) reviewed the engineering accreditation criteria of the Washington Accord, the United States (ABET) and Australia (Engineers Australia) and recommended that accreditors strengthen the guidelines to encourage universities to improve their design curriculum in line with contemporary best practices. This paper extends that work to all 25 Washington Accord member countries but focuses specifically on a comparison of the design criteria. This comparison will indicate the common accreditation specifications of capstone design projects to provide a basis for the future investigation of leading practices in engineering capstone design in Australia.

Background

Relationship between accreditation and regulatory schemes

The Washington Accord (IEA, 2014) is an international agreement between the member countries' accrediting bodies to facilitate engineering graduates' mobility and to advance the recognition of good practice in engineering education. The Washington Accord specifically focuses on the Professional Engineer level, while the other accords cover Engineering Technologists and Engineering Technicians. Typically, Professional Engineers undertake 4 years of tertiary study, although this qualification may also be granted after a combination of undergraduate and postgraduate study, including 'entry to practice masters' or 'integrated masters' courses.

The Washington Accord uses Outcomes Based Education as a framework to develop and assess the demonstration of graduate attributes, equivalent in some jurisdictions to program outcomes or competency standards. Each member country may adopt the Graduate Attributes or adapt them for its own context. However, adapted attributes must align with the Washington Accord Graduate Attributes (IEA, 2021).

Dual accreditation serves as a precedent for the comparisons in this study. The Washington Accord allows dual accreditation, meaning multiple countries' accreditation schemes may simultaneously govern a single program. Dual accreditation acknowledges the goal of a common understanding of the interpretation of different countries' graduate attributes under the Washington Accord, even if accreditors may customise the specific wording for their local context (Kootsookos et al., 2017).

Additionally, programs may be subject to quality assurance and regulatory requirements under national schemes (in Australia, the Tertiary Education Quality and Standards Agency) as well as institutional policies and procedures (at the author's institution, for example, the course design requirements of an integrated Honours year as a fourth year of undergraduate study).

Capstone design

Capstone design projects are a culminating design experience in an engineering program. Common elements of a capstone project typically include “problem-based learning precursor courses, group project emphasis, design-build-test model, active industry involvement, and sequential assignments” (Ward, 2013). From the students’ perspective, a capstone design experience provides the opportunity to develop an engineering identity, knowledge of the design process, connections to the ‘real world’, project management skills, self-directed learning and teamwork skills (Lutz et al., 2015). From an accreditation perspective, the role of a capstone design experience is usually to evidence graduate-level outcomes in design and interrelated competencies such as applying technical knowledge, communication, teamwork and stakeholder engagement.

Practically, the implementation of capstone design varies across countries and institutions. For example, a capstone design subject may have a common project or may comprise many staff, student or industry-generated projects (Howe, 2018). The major study in this area is a decadal survey on capstone design conducted in the United States. Starting in the mid 1990s, the first report noted it was difficult to characterise all experiences using one survey due to differences in disciplines and educational environments (Todd et al., 1995). The second survey in 2005 indicated an increase in team size and the proportion of interdisciplinary projects (Howe, 2010). The report on the 2015 survey indicates that class sizes and the number of entrepreneurial projects have increased (Howe et al., 2017). The 2015 survey included some Australian and New Zealand capstone design teachers; however, they did not report any separate results for this cohort. The limitations of existing studies on capstone design are that most in-depth studies relate to single programs or disciplines, and no large-scale studies are found in the Australian context.

In practice, Australian engineering educators commonly understand the capstone design experience to be either:

- A team-based design project, integrating previous studies, as the final subject in a sequence of units (Integrated Design Project, IDP), or
- An individual or team-based final year project, sometimes in the form of a thesis, incorporating major design elements (Final Year Project, FYP).

In the Australian context, an FYP may entirely be research-based - there is usually no requirement for it to include design. The outcomes for these two types of projects, IDP and FYP, overlap but are not identical. This paper focuses specifically on the stated accreditation criteria for capstone design, whatever form that may take.

Methods

Scope

The 25 Washington Accord signatory countries with full rights of participation as of July 2024 (IEA, n.d.) are in scope for this study. Each country’s official accreditation agency website was accessed to collate publicly available accreditation documents. 68 relevant criteria, manuals, procedures, standards, definitions, guidance notes, handbooks, self-study reports, and instructions for evaluators were reviewed, of which 47 were considered to be within the scope of this study. Documents were considered in scope if they contributed to one of the following focus areas:

1. Definitions of Engineering Design
2. Requirements for program structures to incorporate design
3. Specifications for capstone projects

Items out of scope for this study include discipline-specific design criteria, design criteria related to experimental design, design criteria related to communication, qualifications of design teaching staff, and labs and infrastructure to support design projects.

Only official English translations of accreditation documents were used; documents not in English were considered out of scope. Every member country provided at least one document in English mentioning design, although some self-study report templates had no official translation.

The United Kingdom uses discipline professional bodies to conduct accreditation, therefore, the iMechE criteria were used as an equivalent example at the MEng level.

Method

Qualitative content analysis was employed to review all instances of the word ‘design’ and derive their contribution to the focus areas. Each document was also reviewed for specific instructions regarding requirements and specifications for ‘capstone’, ‘thesis’ or ‘final year’ projects or experiences. Analysis was focused on design projects. However, comparisons to research projects were included where found. Quantitative content analysis was not performed due to the disparate nature of the documents - some documents reprint Washington Accord criteria or include template examples, which skew the volume of results without providing additional insight. All documents were reviewed by the author, avoiding potential issues of inter-rater reliability. Both deductive and inductive coding were utilised, as although the themes were well defined before starting to review the documents, the coding of the data was refined as the analysis was conducted.

Results and Discussion

A definition of engineering design

Dym et al. (2005) proposed a definition for Engineering Design:

> *Engineering design is a systematic, intelligent process in which designers generate, evaluate, and specify concepts for devices, systems, or processes whose form and function achieve clients’ objectives or users’ needs while satisfying a specified set of constraints.*

The components of this definition <behaviours, processes, meeting requirements, within constraints> are substantially similar to the definitions found within the current accreditation standards. However, in the 20 years following this definition, what has been added is an acknowledgement of the context within which design happens, which can be seen in the current Washington Accord Graduate Attribute Profiles and Knowledge and Attitude Profile (IEA, 2021) (Table 1).

Table 1: Washington Accord design criteria

WA3: Design creative solutions for complex engineering problems and design systems, components or processes to meet identified needs **with appropriate consideration for public health and safety, whole-life cost, net zero carbon as well as resource, cultural, societal, and environmental considerations as required**	WK5: Knowledge, including efficient resource use, environmental impacts, whole-life cost, re-use of resources, net zero carbon, and similar concepts, that supports engineering design and operations in a practice area

All countries specified an outcome related to design, whether they adopted the Washington Accord criteria directly or adapted one for their local context. 10/25 countries additionally specified a definition for engineering design outside their graduate attributes, program outcomes or competency standards (Table 2). Several additional themes are found in these definitions [count of countries in brackets], including creativity [8], open-ended [5], integration [4], decision-making [4], and iteration [4].

Table 2: Engineering design definitions
[Creativity, Open-ended, Integration, Decision-making, Iteration]

Australia (Engineers Australia, 2019b)	Engineering application ability (especially design), which is the creative bridge between human needs and the technical elements of the solution.
Canada (Engineers Canada, 2023)	Engineering design is a process of making informed decisions to creatively devise products, systems, components, or processes to meet specified goals based on engineering analysis and judgement. The process is often characterized as complex, open-ended, iterative, and multidisciplinary. Solutions incorporate natural sciences, mathematics, and engineering science, using systematic and current best practices to satisfy defined objectives within identified requirements, criteria and constraints. Constraints to be considered may include (but are not limited to): health and safety, sustainability, environmental, ethical, security, economic, aesthetics and human factors, feasibility and compliance with regulatory aspects, along with universal design issues such as societal, cultural and diversification facets. Engineering design integrates mathematics, natural sciences, engineering sciences and complementary studies in order to develop elements, systems and processes to meet specific needs. It is a creative, iterative and open-ended process, subject to constraints which may be governed by standards or legislation to varying degrees depending upon the discipline. These constraints may also relate to economic, health, safety, environmental, societal or other interdisciplinary factors.
Costa Rica (CFIA, 2018)	Engineering design integrates knowledge in mathematics, basic sciences, engineering sciences, and complementary courses in the development of elements, systems, and processes to meet specific needs. It is a creative, iterative, and usually open-ended process subject to the restrictions of the technical standards and economical, social, legal, environmental, and occupational health and safety aspects or those of an interdisciplinary nature.
Indonesia (IABEE, 2020)	Engineering design is the process of devising a system, component, or process to meet desired needs. It is a decision making process, in which the basic sciences, mathematics, and the engineering sciences are applied to convert resources optimally to meet the stated needs.
Japan (JABEE, 2019)	"Design Ability" is necessary ability "to identify feasible solution to the problem with multiple possible solutions by applying various disciplines and technologies" … In the actual design, it is expected to comprehensively perform conception ability, problem setting ability, comprehensive ability to apply various disciplines and technologies, creativity, ability to recognize problem from the perspective of public health & safety, culture, economy environment and ethics and ability to identify solution under the constraints produced by those problem, ability to verify result, ability to express thoughts in figures, sentences, formula and programs, communication ability, ability to work in a team and ability to continuously plan and implement although, those abilities for design covers in width and depth.
Mexico (CACEI, 2020)	Understood as the integration of mathematics, natural sciences, engineering sciences, and complementary studies for the development of elements, systems, and processes to satisfy specific needs. This is a creative, interactive and open process, subject to the limitations governed by rules or legislation to varying degrees depending on the discipline. They may relate to economic, health, safety, environmental, social, or other interdisciplinary aspects.
Philippines (PTC, 2019)	Engineering Design and Synthesis: is the creative, iterative and often open-ended process of conceiving and developing components, systems and processes. Design projects must include complex engineering problems requiring integration of engineering, basic and mathematical sciences, working under constraints, taking into account economic, health and safety, social and environmental and sustainability factors, codes of practice and applicable laws, and standards in the field.

South Africa (ECSA, 2020)	Engineering design and synthesis: constitutes the systematic process of conceiving and developing materials, components, systems and processes to serve useful purposes. Design may be procedural, creative or open-ended and requires the application of engineering sciences, working under constraints, and taking into account economic, health and safety, social and environmental factors, codes of practice and applicable laws.
United Kingdom (Engineering Council, 2020)	Design is the creation and development of an economically viable product, process or system to meet a defined need.
United States (ABET, 2023)	Engineering design is a process of devising a system, component, or process to meet desired needs and specifications within constraints. It is an iterative, creative, decision-making process in which the basic sciences, mathematics, and engineering sciences are applied to convert resources into solutions. Engineering design involves identifying opportunities, developing requirements, performing analysis and synthesis, generating multiple solutions, evaluating solutions against requirements, considering risks, and making trade-offs, for the purpose of obtaining a high-quality solution under the given circumstances. For illustrative purposes only, examples of possible constraints include accessibility, aesthetics, codes, constructability, cost, ergonomics, extensibility, functionality, interoperability, legal considerations, maintainability, manufacturability, marketability, policy, regulations, schedule, standards, sustainability, or usability.

Based on the analysis above, the author proposes a meta-definition:
Engineering design is the process of developing solutions to problems that meet requirements within constraints in a context.

And, for discussion, an updated detailed definition for the purposes of further study:
Engineering design is a creative, open-ended and iterative process of developing, selecting and justifying the most appropriate solution to a problem. It requires applying engineering technical and professional skills to define and meet requirements and stakeholder expectations within constraints such as cost, time, resources, legislation and standards, and considering the social, ethical, health and safety, environmental and sustainability impacts.

Capstone design project

Engineers Australia (2019b) specifies that there must be a major project incorporating design within the curriculum:

> *It is expected that programs will embody at least one major engineering project experience, which draws on technical knowledge and skills, problem solving capabilities and design skills from several parts of the program and incorporates broad contextual considerations as part of a full project life cycle. Students should work independently and in teams.*

However, this must be read in conjunction with the accreditation procedures (Engineers Australia, 2019a) to determine that this should be at the final year level:

> *A representative range of graded final year design projects and theses… To judge the standard of capstone activities; to assist in determining that final year students are able to undertake individual and group major project work; that they are ready for the professional workplace.*

19/25 countries specify a significant or culminating design experience at the final year level (Table 3). No stated requirement for a final design project was found for India, Ireland or Peru. As of 2019, year-long Final Year Design Project or Capstone Projects are no longer required for Bangladesh, however, they are the preferred method of evidencing complex open-ended problem solving (BAETE, n.d.). Japan does not specify that design must be taught in the final year, however it is specified that if an undergraduate research course is deemed as the only design course, then it must include design knowledge, as “undergraduate research won’t be recognized as design education if students just follow the instructions of supervisors” (JABEE, 2010). South

Africa allows either design or laboratory/investigation projects (ECSA, 2018). Malaysia (BEM, 2024), Sri Lanka (IESL, 2023) and the United Kingdom (IMechE, 2023) require both a group capstone design and an individual investigative project. New Zealand (Engineering New Zealand, 2024) and Russia (AEER, 2014) require both design and research, but these are allowed to be part of the same project or separate projects.

Table 3: Accreditation stated final design project requirements

	ONLY		AND	OR	NONE
Design Project	Australia Canada China Costa Rica Hong Kong Indonesia Korea Mexico	Pakistan Philippines Singapore Taiwan Turkey United States of America	Malaysia New Zealand* Russia* Sri Lanka United Kingdom * Can be in the same project	South Africa	Bangladesh^ India Ireland Japan Peru ^ Final Year Design Project or Capstone Project preferred but not required
Research Project					

Australian programs typically, but not always, include both a capstone team-based design subject and a final year project, which may be design based but must involve research to meet AQF requirements (Australian Qualifications Framework Council, 2012). The author's institution sets further requirements in the integrated honours 4th year for a final year thesis-like project, which must be assessed individually but may be conducted as a team. More investigation is required to determine current practices in design and final year projects in Australian courses. Throughout the criteria for capstone design, accrediting bodies specified varying degrees of integration of previous sub-disciplines of study. Future work will also explore the role and practice of integration.

Design spine

Engineers Australia (2019b) states that "Ideally a program will contain multiple design tasks, project activities, and research (as appropriate) throughout all stages of the program." The Canadian criteria and procedures are elegant in describing a best practice articulated design program - "appropriate design education weaves through programs as a connecting thread. In a well-configured program, a design course would occur in every academic year at a level commensurate with a student's abilities." (Engineers Canada, 2023).

Very few accreditation documents specified requirements for or approaches to scaffolding design throughout the course, sometimes known as a 'design spine'. Those that did generally did so through credit point minimums, necessitating the inclusion of design before the final year but not specifying at what year level or how continuously this must be done. In the 1990s, there was a resurgence of first-year design to address the disconnect between early fundamentals and sudden application in final year (Dym et al., 2005). However, this has still not been consistently connected through the middle years, forming a 'gulf in student experience' (Froyd et al., 2012).

Conclusion

Accreditation criteria form a useful standard from which to constructively align and continuously review the engineering curriculum. The criteria should not be viewed as a check-box exercise nor a restriction preventing advanced or innovative practice. Through a thorough review of 25 countries' accreditation criteria on design, what is clear is that specific standards are far easier to implement and measure against than those requiring interpretation or triangulation of multiple sources. This author is aware that other private guidelines exist, e.g., instructions for panels, which could not be included in this study. Furthermore, we can observe in practice that panel members do give weight to what is customary or historical, not just what is specified. Future work will explore practice in engineering capstone design and reflect on whether practice meets, exceeds or should change the accreditation criteria.

Engineering capstone design projects are required in almost all Washington Accord member countries. Very few countries specify a requirement for design between the first and final years, yet this is considered good educational practice. Advances in contemporary definitions of engineering design include the contexts in which design takes place and could be extended to recognise the creative nature of engineering problem solving.

Finally, in conversations about capstone design in the Australian context, there is still confusion about whether we are discussing an IDP or an FYP. Defining these projects, surveying their implementation across Australian programs and collecting specifications such as credit points and semesterisation will allow better design for further research, collaboration, industry integration and equitable application of accreditation standards.

References

ABET. (2023). *Criteria for accrediting engineering programs: Effective for reviews during the 2024-2025 accreditation cycle*. Accreditation Board for Engineering and Technology. https://www.abet.org/wp-content/uploads/2023/05/2024-2025_EAC_Criteria.pdf

AEER. (2014). *Accreditation criteria guide*. Association for Engineering Education of Russia. https://aeer.ru/filesen/accred/2014_Criteria_B_en.docx

Australian Qualifications Framework Council. (2012). *Research: An explanation.* https://www.aqf.edu.au/download/412/research/6/research/pdf

BAETE. (n.d.). *ACC-MAN-02 v3.0*. Board of Accreditation for Engineering and Technical Education. Retrieved October 3, 2024, from https://www.baetebangladesh.org/acc-man-02-v3-f.html

BEM. (2024). *Engineering Programme Accreditation Standard 2024*. Board of Engineers Malaysia http://bem.org.my/documents/20181/314738/Engineering-Programme-Accreditation-Standard-2024.pdf/0e29a923-07f0-4fca-a1ea-be8974e30244

CACEI. (2020). *2018 Reference Framework for Engineering*. Consejo de Acreditación de la Enseñanza de la Ingeniería, Asociación Civil. https://cacei.org.mx/nv/nvdocs/appendixe.pdf

CFIA. (2018). *Accreditation criteria*. Colegio Federado de Ingenieros y de Arquitectos de Costa Rica. https://aapia.cfia.or.cr/wp-content/uploads/2018/01/accreditationCriteria.pdf

Dym, C. L., Agogino, A. M., Eris, O., Frey, D. D., & Leifer, L. J. (2005). Engineering Design Thinking, Teaching, and Learning. *Journal of Engineering Education* (Washington, D.C.), 94(1), 103–120. https://doi.org/10.1002/j.2168-9830.2005.tb00832.x

Engineering Council. (2020). *Accreditation of Higher Education Programmes: UK Standard for Professional Engineering Competence (4th ed.)*. https://www.engc.org.uk/media/3410/ahep-fourth-edition.pdf

ECSA. (2018). *Accreditation criteria guide*. Engineering Council of South Africa. https://www.ecsa.co.za/education/EducationDocs/E-12-P.pdf

ECSA. (2020). *Qualification standard for Bachelor of Science in Engineering (BSc(Eng))/Bachelors of Engineering (BEng)*. Engineering Council of South Africa. https://www.ecsa.co.za/ECSADocuments/Shared%20Documents/E-02-PE%20Qualification%20Standard%20for%20Bachelor%20of%20Science%20in%20Engineering%20(BSc(Eng))%20Bachelors%20of%20Engineering.pdf

Engineering New Zealand. (2024). *Accreditation criteria: Version 4.1*. https://d2rjvl4n5h2b61.cloudfront.net/media/documents/ACC_02_Accreditation_Criteria_V4.1_FINAL_10-May-2024.pdf

Engineers Australia. (2019a). *Accreditation management system: Procedures manual for higher education.* https://www.engineersaustralia.org.au/sites/default/files/2022-07/accreditation-management-system-2019-procedures-manual-higher-education.pdf

Engineers Australia. (2019b). *Accreditation criteria user guide: Higher education*. https://www.engineersaustralia.org.au/sites/default/files/2022-07/accreditation-criteria-guide-higher-education.pdf

Engineers Canada. (2023). *Accreditation criteria and procedures*. https://engineerscanada.ca/sites/default/files/2023-12/Accreditation_Criteria_Procedures_2023.pdf

Froyd, J. E., Wankat, P. C., & Smith, K. A. (2012). Five Major Shifts in 100 Years of Engineering Education. *Proceedings of the IEEE, 100*(Special Centennial Issue), 1344–1360. https://doi.org/10.1109/JPROC.2012.2190167

Hadgraft, R. G. (2017). Rethinking Accreditation Criteria to focus on Design. *2017 7th World Engineering Education Forum (WEEF)*, 802–807. https://doi.org/10.1109/WEEF.2017.8467080

Howe, S. (2010). Where Are We Now? Statistics on Capstone Courses Nationwide. Advances in engineering education, 2(1), n1.

Howe, S., Rosenbauer, L., & Poulos, S. (2017). The 2015 capstone design survey results: Current practices and changes over time. International Journal of Engineering Education, 33(5), 1393.

Howe, S. (2018). Cultivating the Capstone Ecosystem to Educate the Engineer of 2020. International Journal of Engineering Education, 34(2 (B)), 653.

IABEE. (2020). *Accreditation criteria for engineering programs*. Indonesian Accreditation Board for Engineering Education. https://iabee.or.id/wp-content/uploads/2020/02/Accreditation-Criteria-ENG-Version-2020.pdf

IESL. (2023). *Accreditation Manual for Engineering Degree Programmes (According to Washington Accord)*. Institution of Engineers, Sri Lanka. https://app.box.com/s/a9pk6dhdbejutvl84x279oqiveags2iq

IMechE. (2023). *Academic accreditation guidelines: September 2023*. Institution of Mechanical Engineers. https://www.imeche.org/docs/default-source/1-oscar/membership/universities/july-2023/imeche_academic_accreditation_guidelines_september_2023.pdf?sfvrsn=2

IEA. (n.d.). *Washington Accord signatories.* International Engineering Alliance. Retrieved July 29, 2024, from https://www.internationalengineeringalliance.org/accords/washington/signatories

IEA. (2014). *25 years of the Washington Accord: Celebrating international engineering education standards.* International Engineering Alliance. Retrieved from https://www.internationalengineeringalliance.org/assets/Uploads/Documents/History/25YearsWashingtonAccord-A5booklet-FINAL.pdf

IEA. (2021). *Graduate attributes and professional competencies (Version 2021.1)*. International Engineering Alliance. https://www.internationalengineeringalliance.org/assets/Uploads/Documents/IEA-Graduate-Attributes-and-Professional-Competencies-2021.1-Sept-2021.pdf

JABEE. (2010). *Examination and accreditation guideline on EDE*. Japan Accreditation Board for Engineering Education. https://jabee.org/doc/Examination_Accreditation_Guideline_on_EDE.pdf

JABEE. (2019). *Criteria guide for accreditation of engineering education programs at bachelor level*. Japan Accreditation Board for Engineering Education. https://jabee.org/doc/Criteria_Guide_ENB_2019-.pdf

Kootsookos, A., Alam, F., Chowdhury, H., & Jollands, M. (2017). Offshore Engineering Education: Assuring Quality Through Dual Accreditation. *Energy Procedia*, *110*, 537–542. https://doi.org/10.1016/j.egypro.2017.03.181

Lee, P., Crosthwaite, C., Reidsema, C., Burnett, I., Foley, B., Hargreaves, D., King, R., Lamborn, J., Symes, M., & Wilson, J. (2022). Preparing Engineers for 2035: Transforming Australia's Engineering Education for Emerging Roles and Expectations. In *Applied Degree Education and the Future of Learning* (pp. 29–52). Springer Nature Singapore. https://doi.org/10.1007/978-981-16-9812-5_2

Lutz, B. D., Ekoniak, M., Paretti, M. C., & Smith-Orr, C. (2015). Student perspectives on capstone design learning. *Atlanta: American Society for Engineering Education-ASEE*. https://doi.org/10.18260/p.24762

PTC. (2019). *CASEE manual V.2: Accreditation criteria*. Philippine Technological Council. https://ptc.org.ph/wp-content/uploads/2019/11/CASEE-Manual-V.-2-Accreditation-Criteria-.pdf

Todd, R. H., Magleby, S. P., Sorensen, C. D., Swan, B. R., & Anthony, D. K. (1995). A Survey of Capstone Engineering Courses in North America. *Journal of Engineering Education (Washington, D.C.)*, 84(2), 165–174. https://doi.org/10.1002/j.2168-9830.1995.tb00163.x

Ward, T. A. (2013). Common elements of capstone projects in the world's top-ranked engineering universities. *European Journal of Engineering Education*, 38(2), 211–218. https://doi.org/10.1080/03043797.2013.766676

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