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Evaluating and Enhancing the Efficacy of the Community-Centered Learning and Teaching Pedagogy in an Engineering Course

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ABSTRACT

CONTEXT

Charles Sturt University (CSU) Engineering incorporates modern engineering education by introducing a community-centred pedagogy in its curriculum, which is informed by contemporary engineering education research. This innovative approach moves beyond traditional classroom teaching methods to incorporate real-world contexts, emphasising problem-solving skills, cultural competency, and social responsibility. Students participate in human-centred design activities while communicating with clients through a central platform during their initial year. The following year, they collaborate on projects sourced from the community, presenting prototypes and interacting directly with clients. Afterwards, students undertake cadet placements, fulfilling clients' requirements while acquiring hands-on experience in the industry.

PURPOSE

The scholarly project proposes a comprehensive evaluation of the efficacy of the community-centred pedagogy employed at CSU Engineering. By utilising thematic analysis of the student subject experience survey transcripts from multiple cohorts, the project aims to provide empirical evidence of the approach's impact on students' learning outcomes and professional development. This rigorous evaluation contributes to the scholarship of teaching and learning in engineering education, guiding future curriculum development efforts. Ultimately, the project seeks to inform and refine the engineering curriculum's community-centered approach.

METHODOLOGY

We collected the student subject experience survey results across three subjects (first-year first session, first-year second session, and second-year first session) spanning nine years. We used the thematic analysis, a qualitative analysis of texts and transcripts, and identified major themes to inform effective teaching practices.

OUTCOMES

A checklist was formulated as a result of the thematic analysis. This checklist covers subject design and delivery strategies to enhance students' success.

CONCLUSIONS

The checklist can be used to ensure consistent and quality teaching of project-based engineering curriculums.

KEYWORDS

community-centered pedagogy**,** thematic analysis**,** interview**,** Efficacy**,** experiential learning**,**
seven cohorts**,** Charles Sturt University Engineering

Introduction

Charles Sturt University (CSU) Engineering incorporates modern engineering education by introducing a community-centred pedagogy in its curriculum, which is informed by contemporary engineering education research (Smith & Browne, 2014). This innovative approach moves beyond traditional classroom teaching methods to incorporate real-world contexts, emphasising problem-solving skills, cultural competency, and social responsibility. Students participate in human-centred design activities while communicating with clients through a central platform during their initial year. The following year, they collaborate on projects sourced from the community, presenting prototypes and interacting directly with real-world clients. Afterwards, students undertake cadet placements, fulfilling clients' requirements while acquiring hands-on experience.

By integrating human-centred design principles and engaging students in community-sourced projects, the curriculum emphasises the practical application of engineering skills from the early years of study. The curriculum incorporates experiential learning through placements as cadets, providing students practical experience while addressing clients' needs. This experiential component is crucial for bridging the gap between theoretical knowledge and real-world application, equipping students with the skills and competencies required for their future careers as engineers (Kolmos et al., 2014). This hands-on approach enhances students' understanding of engineering concepts and prepares them to navigate real-world challenges with empathy and collaboration, which are essential for success in the field (Besterfield-Sacre et al., 2015; Froyd et al., 2020).

The scholarly project proposes a comprehensive evaluation of the efficacy of the community-centred pedagogy employed at CSU Engineering. By utilising thematic analysis of student subject experience surveys from multiple cohorts, the project aims to provide empirical evidence of the approach's impact on students' learning outcomes and professional development. This rigorous evaluation contributes to the scholarship of teaching and learning in engineering education, guiding future curriculum development efforts (Miller et al., 2017). Ultimately, the project seeks to inform and refine the engineering curriculum's community-centered approach. By cultivating socially responsible engineers with empathy, collaboration, and sustainability at their core, the project aligns with broader societal needs for ethical and responsible engineering practices. The focus on social responsibility reflects a paradigm shift in engineering education towards producing responsible engineering graduates who are technically proficient, ethically conscious, and socially equipped to address contemporary societal challenges (Godfrey et al., 2018).

Background and Motivation

The growing recognition of the need for innovative teaching methodologies in engineering education has catalysed the exploration of community-centred learning and teaching pedagogy. This approach, which emphasises collaborative learning, real-world problem-solving, and community engagement, aims to bridge the gap between theoretical knowledge and practical application. Traditional engineering education often struggles to keep pace with the rapidly evolving demands of the industry, resulting in graduates who may lack critical skills in teamwork, communication, and contextual understanding. This pedagogy can enhance student engagement, retention, and overall learning outcomes by fostering a learning environment where students actively participate in their education and apply their skills to community projects.

The motivation for this research stems from the need to systematically evaluate the efficacy of community-centred learning in an engineering context and to identify strategies for its effective implementation. Through this study, by examining the current CSU engineering practices, we seek to contribute to the broader discourse on educational innovation and to provide evidence-based recommendations for engineering educators looking to adopt more holistic and impactful teaching practices.

Understanding the Data

The raw data source comes from the student subject experience survey results collected from 2016 to 2024, spanning nine years, for the three major subjects. The qualitative data comprises students' subjective answers to the following two questions: "What about this subject did you find most helpful in your learning?" and "What about this subject did you find least helpful in your learning?". Please note that our research question is: What are the best practices and areas of improvement when applying community-centred pedagogy in a project-based education model? Therefore, not all answers were necessarily applicable within the dataset. Some answers or comments might be on the general approach to teaching. Therefore, upon initial study, some comments were removed, such as using tools such as "pebblepad", "sparkplus". In addition, the data captured two subjects' online offerings due to COVID-19. Comments regarding the online learning experiences were also removed, as these subjects were designed for face-to-face teaching. The delivery of these subjects has now returned to face-to-face. Open text comments from students during the switch to online delivery have also been removed from the data, with two examples provided below.

> *Some obvious difficulties with implementing the subject via online delivery.*
>
> *The lack of interaction in the workshops, due to online learning it was difficult to stay fully engaged in the workshops without that physical interaction.*

Furthermore, comments about the students were removed, for example:

> *There were some people who were really selfish towards their ideas being put forward. As a project that involves the whole cohort's corporation, it is very important that we collaborate and cooperate. However, there were 4-5 students who ONLY wanted their ideas to be put forward. This made the subject at least 5 times harder than what it should be.*

The early impressions to the question "What about this subject did you find *most* helpful?" resulted in common keywords across student responses, such as: 'mentor', 'teamwork and collaboration', 'clarity and simplicity of the subject design', 'structured community-centred design approach', 'real-world projects', 'actual client interaction', 'guest speakers from industry', 'teaching staff approachability' and the 'style of teaching'.

The early impressions to the question "What about this subject did you find *least* helpful in your learning?" resulted in comments such as: 'inconsistency between the teaching staff and the mentors', 'subject outline (assessment requirements) and the marking rubrics were ambiguous', 'lack of information and guidance', 'feedback not informing the following assessment, either because of timing or quality', 'teamwork', 'the degree of challenge for students', and 'uncertainties'.

Materials and Data

Subject information

These subjects, as listed below, have been taught by staff with various experiences, including academics with PhD degrees, specialising in engineering education and broad civil engineering disciplines. There are also engineers in residency who have worked in industry. Some subjects were taught by a team of two due to work allocation. All subjects have a dedicated convenor who would engage staff members with specialities to mentor students' projects. The mentors' role is to ensure that student teams have adequate technical support.

ENG161: Challenge 1- First year, first session– 14 weeks, 14 credit points:

Subject Abstract: This subject draws upon the Engineers Without Borders annual challenge to provide teams of student engineers the opportunity to solve real-world problems with human dimensions. Student engineers work in teams to respond to the Engineers Without Borders challenge, and will then have to communicate their achievements to engineers and nonengineers. The development of technical, teamwork and communication skills are supported as student engineers begin to develop the Charles Sturt Engineering mindset.

Learning outcomes:

- articulate and incorporate considerations of the ethical, social, cultural, global and environmental responsibilities of the professional engineer in solving an engineering problem;
- apply the principles of sustainable design in a development context;
- implement and evaluate planning processes and employ project management skills to solve an engineering problem;
- reflect on the strengths and weaknesses of the team approach to problem-solving in order to enhance teamwork;
- communicate achievements to engineering and non-engineering audiences;
- apply a systems thinking approach to an engineering problem, and utilise the human-centred design process; and
- identify information needs and locate, select, use and reference information from various sources to effectively inform the design process.

ENG162: Challenge 2- First year, second session– 14 weeks, 14 credit points:

Subject Abstract: This subject will continue to develop the student engineers' professional identities and capabilities from ENG161, while drawing upon the technical skills developed via the topic tree. Student engineers will work in teams to tackle a session-long engineering challenge in the civil context with social, environmental, economic and human dimensions. In particular, this challenge will focus student engineers' efforts on the norms of engineering practice, the management of engineering projects, the feasibility of their solutions, the engagement with people outside of their design team, and the communication of their ideas and designs to both technical and non-technical audiences.

Learning outcomes:

- produce technically feasible solutions to real-world engineering problems through the application of mathematics and numerical analysis;
- plan solutions to engineering problems that incorporate an understanding of the interrelationships between social, environmental, economic, human and technical factors and apply appropriate methodologies throughout the design process to produce a creative and sustainable engineering design;
- present technical information in a professional manner, in written, verbal, numerical and graphical formats, both synchronously and asynchronously;
- demonstrate initiative, accountability and effective communication as members of an engineering team;
- objectively reflect upon one's work, the work of others and the management of the project;
- conduct background research on applicable engineering content and synthesise the knowledge to apply to the design project; and
- demonstrate understanding of the scope and professional accountabilities of civil engineering practice on the design project and integrate the norms of practice into the conduct and management of the project.

ENG261: Challenge 3 - Second year, first session– 14 weeks, 14 credit points:

Subject Abstract: This subject will further develop the student engineers' identity through a team-based session-long practical project. Student engineers will deliver workable engineering solutions to real world problems sourced from community clients. Student engineers are to apply engineering fundamental principles, methods and tools when formulating the solutions. Skills in, but not limited to, the following aspects will be further enhanced beyond what has been introduced in ENG161 and ENG162: project management, designing, researching, implementing, teamwork, communication, and offering and receiving feedback. This subject offers student engineers opportunities to practice and reflect upon their practice as engineers, both individually and in groups. This subject serves as a bridging pathway for student engineers to embark on their first work placements.

Learning outcomes:

- apply underpinning sciences and engineering fundamentals to systematically devise a workable solution to a real-world engineering problem, considering social, economic and environmental sustainability;
- articulate and follow systematic engineering design processes;
- identify the hallmarks of high performance teams and the necessity for varieties of roles, and identify strengths and opportunities for improvement in a team environment;
- research, assess and synthesise information from a range of engineering resources, use appropriate artifacts within the engineering discipline to communicate with and engage different audiences;
- offer constructive feedback to peers, incorporate comments from peers/mentors and justify their acceptance and rejection; and
- develop and reflect on their emerging identity as student engineers, and how this will change as they move into placement in industry.

Thematic Analysis

We used Braun & Clarke's (2006) six-step framework to perform the thematic analysis. Herein, we used a theoretical (top-down) thematic analysis, meaning that it is driven by the specific research questions rather than a (bottom-up) inductive one driven by the collected data.

Initial coding

In this initial coding stage (abstracting the content by forming categories), the student experience survey results were analysed, and relevant themes or patterns related to the community-centred pedagogy were identified and labelled. We used the open-code approach and modified the codes as we progressed.

For example, 33 codes were extracted and generated to the question: What about this subject did you find most helpful in your learning?

1. Regular mentor meetings facilitated personal and team development, providing motivation and direction.
2. Teamwork in researching and completing tasks encouraged collaboration and shared knowledge.
3. Successfully completing tasks despite missing team members, leveraging diverse team backgrounds for problem-solving.
4. Tasks were presented with clarity and simplicity, making them easy to follow and complete.
5. Report writing, structured work, teamwork, and communication skills were significantly improved with mentor guidance.
6. Classes were engaging and helpful, with accessible slides for review when sessions were missed.
7. Real-life scenarios provided exposure to workforce experiences, enhancing industry skills.
8. Various course components were well-connected, with feedback from presentations improving designs and documentation.
9. The human-centered design process was thoroughly learned and applied, providing valuable knowledge.
10. Workshops provided a clear understanding of how to complete various tasks effectively.
11. A range of design areas allowed for exploration of interests, and cohort collaboration enhanced learning.

12. Detailed feedback from mentors and other academics improved the quality of submitted work and overall learning experience.
13. Team projects facilitated collaboration and accelerated the learning process.
14. The focus on research was beneficial in enhancing the learning process.
15. Lectures from specific instructors were particularly engaging and informative.
16. Learning the engineering design process enabled the creation of effective and methodical designs.
17. Guest lecturers and mentors provided valuable insights, ideas, and resources.
18. Working on real engineering problems allowed for the creation of practical and beneficial.
19. The challenge was well-structured, fostering teamwork and maintaining engagement throughout.
20. The course helped in developing empathy towards end-users, making better engineers.
21. Weekly classes provided necessary structure and kept students on track with their work.
22. Communication with peers and learning from their experiences enriched the learning process.
23. Staff were instrumental in helping improve and refine ideas.
24. Teammates' knowledge and insights contributed significantly to the learning experience.
25. Weekly meetings with mentors and peers were crucial for guidance and support.
26. Report writing and presentations prepared students for future engineering tasks.
27. Enhanced ability to identify problems and tailor solutions to specific criteria.
28. The subject was well-designed to break down complex tasks into manageable components, preventing overwhelm.
29. Research elements in assessments provided a greater understanding of engineering processes.
30. The engineering design process was gradually built up with examples and reviews for better comprehension.
31. Emphasis on the Human-Centered Design Process and the importance of teamwork.
32. Slides and team discussions helped understand and reinforce concepts.
33. Interacting with stakeholders improved resilience and conflict resolution skills, learning to work in changing environments.

Theme search

By examining these codes, several would fit into each other and form a theme. For example, for the extracted 33 codes above, codes 1, 5, 12, 17, 23 and 25 are on the theme of "mentoring"; Codes 2, 3, 11, 13, 19, 22, 24, 25, 31 and 32 are on "working in teams", etc.

By the end of this step, the codes were organised into themes as contributing elements to the answers to the research question. Some codes were associated with one theme, while others were relevant to more than one theme. The resulting themes are listed below:

Table 1: Preliminary theme searching from the initial coding with sample codes

Theme	Extracted codes
Teaching Support and Guidance	• Weekly mentor meetings provided support, development, and motivation. • The influence of guest speakers and mentors provided valuable insights and inspiration. • Inconsistency between the teaching staff and the mentors. • staff availability and level of service to students • There was minimal teaching and lots of self-learning
Teamwork and Collaboration	• Peer collaboration accelerated learning and provided diverse perspectives. • Knowledge and insights from teammates were crucial for learning. • Group efforts developed teamwork skills and achieved objectives.

Theme	Extracted codes
	• Group learning and task delegation improved outcomes and understanding. • Collaborative learning facilitated understanding and skill development. • Personal challenges with team members, including delays and differing contribution levels.
Practical Experience and Real-World Application	• Real-life scenario exposure developed industry skills. • Working on real engineering problems provided practical experience. • The real-world relevance of the subject facilitated the understanding of engineering work. • Practical application in real-world settings was motivating and educational. • Relevance of real clients provided practical and relevant experience.
Human-Centered Design and Research	• Understanding and application of the Human-Centered Design process; • Application of Human-Centered Design Process (HCDP) in team projects; • Research and data collection were essential for project success.
Subject Design	• The subject outline (assessment requirements) and the marking rubrics/ambiguous structure of subject/requirement of tasks/lack of information/guidance/details; • Uncertainties and constant changes; • The assessment is weighted to the back of the session.
Classes and workshops	• Class engagement and access to materials supported learning. • Workshops provided practical understanding and task completion strategies. • Tutorials on specific topics like structural and road engineering were helpful. • Feedback not informing the following assessment, either because of timing or quality • Class is not helpful for the range of projects. • The information presented in lectures conflicted with the information in the rubrics and task descriptions.

Reviewing and refining the themes

We reviewed the themes to devise a checklist to improve the quality of teaching, the level of service to the students, and the contribution to students' success. We referred to the original student subject experience survey quotations and analysed whether the survey results supported the themes. We questioned, for example, if the themes repeat each other; are there any missing themes? This review and refining provided an opportunity to draw out a high intensity of concerns from the raw data.

Under the “Teaching Support and Guidance” theme, several comments identified varying expectations regarding the subject coordinator and the dedicated team mentors. Across the three subjects we reviewed, subject coordinators were responsible for providing student feedback, whereas mentors were to offer technical guidance only and were not part of the marking team. As a result, we decided to create subthemes for subject coordinators and team mentors to cover “Support and Guidance”.

The “Subject Design” theme incorporates “quality of the subject outline” and “design consistency and clarity across assessment tasks, marking rubrics and the alignment to the learning outcomes”. It also showed the importance of subject suitability at the cohort level. Therefore, two subthemes, “quality of the subject outline” and “suitability of the subject design”, were identified for this theme.

Defining themes and writing up

This stage is to make meaning of the themes and produce outcomes – what is next? How does this analysis inform us? What can we continue to do? Moreover, what needs to change?

Herein, a checklist is developed to inform future practices as a result of the thematic analysis. This rigorous evaluation contributes to guiding future curriculum development and, ultimately, to inform and refine the engineering curriculum's community-centred approach to enhance students' success. This can be achieved by providing consistent and well-delivered subjects that align with the Charles Sturt Subject Design Principles.

Table 2. Checklist of quality practices of project-based learning in an Engineering course

Themes	
Teaching Support and Guidance	*Subject coordinators*
	• Students are at the top of the list of priorities in our work profile. • Respond to students' enquiries promptly.
	• Timely feedback: Provide feedback early enough so students can take it to inform their preparation for the upcoming assessment items. • Be sure to include, even start with, positives and commendations. Consider using the structure: commendations – recommendations – commendations. • Useful feedback for commendations: What has done well? And why? (because it shows XXX); for recommendation: what needs improvement? Why does that need improvement? What would I (the subject coordinator) do? Moreover, how will I do it? Show, rather than tell, how to do it. Provide examples; provide resources to students to learn more. • Personalised feedback
	Team mentors
	• Provide technical support for team projects. • Protect the authority of the subject coordinator by referring subject governance matters to the subject coordinator and avoiding multi-sources of communication.
Teamwork and Collaboration	• The ultimate positivity as an outcome of teams with diverse backgrounds, experiences, strengths, motivations, goals, and different contribution levels. • Students improve skills by working in teams in terms of social responsibility, leadership, conflict resolution, conducting difficult conversations, organisation skills, management of team projects, developing empathy, etc.
Practical Experience and Real-World Application	• Understanding engineering with real-world significance is beneficial to students' learning. • The ultimate benefit of managing real-world client interactions and matching subject requirements. This requires monitoring from the subject coordinator. • The chosen real-world projects must be governed by the subject coordinator for quality and merit control to enhance students' learning.
Human-Centered Design and Research	• It is beneficial for first-year students to follow a structured framework of the human-centred design approach. • It is a valuable framework for cultivating students' research/discovery skills, relating and empathising, project scoping, having a holistic awareness of the social, environmental and financial aspects of engineering projects, and being aware of the appropriate solution to the clients, and presenting using the correct terminology to the audiences.
Subject Design	Quality of the outline

Themes	
	• Keep it simple - differentiate core content from supplementary, more in-depth material and eliminate confusing learning content. • Ensure the assessment task descriptions are clear and explicit so that the students understand the expectations and requirements.
	Suitability of the subject design
	• Subject designed to the level of the students and prepare them to grow to the next level progressively;
Classes and workshops	• Ensure that the content is engaging and not just repeating other content. • Be consistent in the structure and progression of content and learning activities throughout the subject so that it is straightforward for students what to expect in each topic (video, reading, learning activity, reflection, etc.) • Ensure that all learning activities are available throughout the content to scaffold learning and skills development required within the assessments. • Provide students explicit guidance on the purpose of learning and how the content and activities prepare them for assessment and professional practice.

Conclusions and Future Study

By conducting the thematic analysis of the student subject experience and survey results of three major project-based learning subjects spanning nine years of cohorts, this study evaluated the quality of teaching practices and identified areas for design and delivery improvements. The identified areas have been formulated into a checklist to promote consistent, quality service to improve students' success. Some major themes include the application of mentoring support, real-world experience with exposure to industry professionals, and subject design regarding assessment and marking. These themes inform the formulation of a checklist that aims to improve the quality of service to students engaged in project-based learning with the community-centred pedagogy in any engineering course.

References

Besterfield-Sacre, M., Atman, C. J., Shuman, L. J., & Van Hecke, A. (2015). Engineering education research and practice. *Journal of Engineering Education, 104*(1), 1-4. https://doi.org/10.1002/jee.20079

Boelt, A. M., Holgaard, J. E., & Kolmos, A. (2023). A thematic analysis of engineering students' experiences of teamwork in problem-based learning. *International Journal of Engineering Education, 39*(3), 627-642. https://doi.org/10.1002/ijee.20322

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77-101. https://doi.org/10.1191/1478088706qp063oa

Froyd, J. E., Wankat, P. C., & Smith, K. A. (2020). Five major shifts in 100 years of engineering education. *Journal of Engineering Education, 109*(4), 595-604. https://doi.org/10.1002/jee.20310

Godfrey, P., Kelly, A., Buckley, P., & Kearney, D. (2018). Engaging students in a transdisciplinary sustainability curriculum. *Sustainability, 10*(10), 3463. https://doi.org/10.3390/su10103463

Kolmos, A., de Graaff, E., & Du, X. (Eds.). (2014). Enhancing quality in higher education: International perspectives. Routledge.

Maguire, M., & Delahunt, B. (2017). Doing a thematic analysis: A practical, step-by-step guide for learning and teaching scholars. All Ireland Journal of Higher Education, 9(3). http://ojs.aishe.org/index.php/aishe-j/article/view/329

Miller, R. L., Umulis, D. M., Besterfield-Sacre, M. E., Atman, C. J., Shuman, L. J., & Van Hecke, A. V. (2017). Educational research, its language, and what engineering education can learn from other disciplines. *Journal of Engineering Education, 106*(1), 1-22. https://doi.org/10.1002/jee.20163

Smith, J., & Browne, C. (2014). A program level approach to community-centred engineering education. In *25th Annual Conference of the Australasian Association for Engineering Education: Engineering the Knowledge Economy: Collaboration, Engagement & Employability* (pp. 528-536). Barton, ACT: School of Engineering & Advanced Technology, Massey University.

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