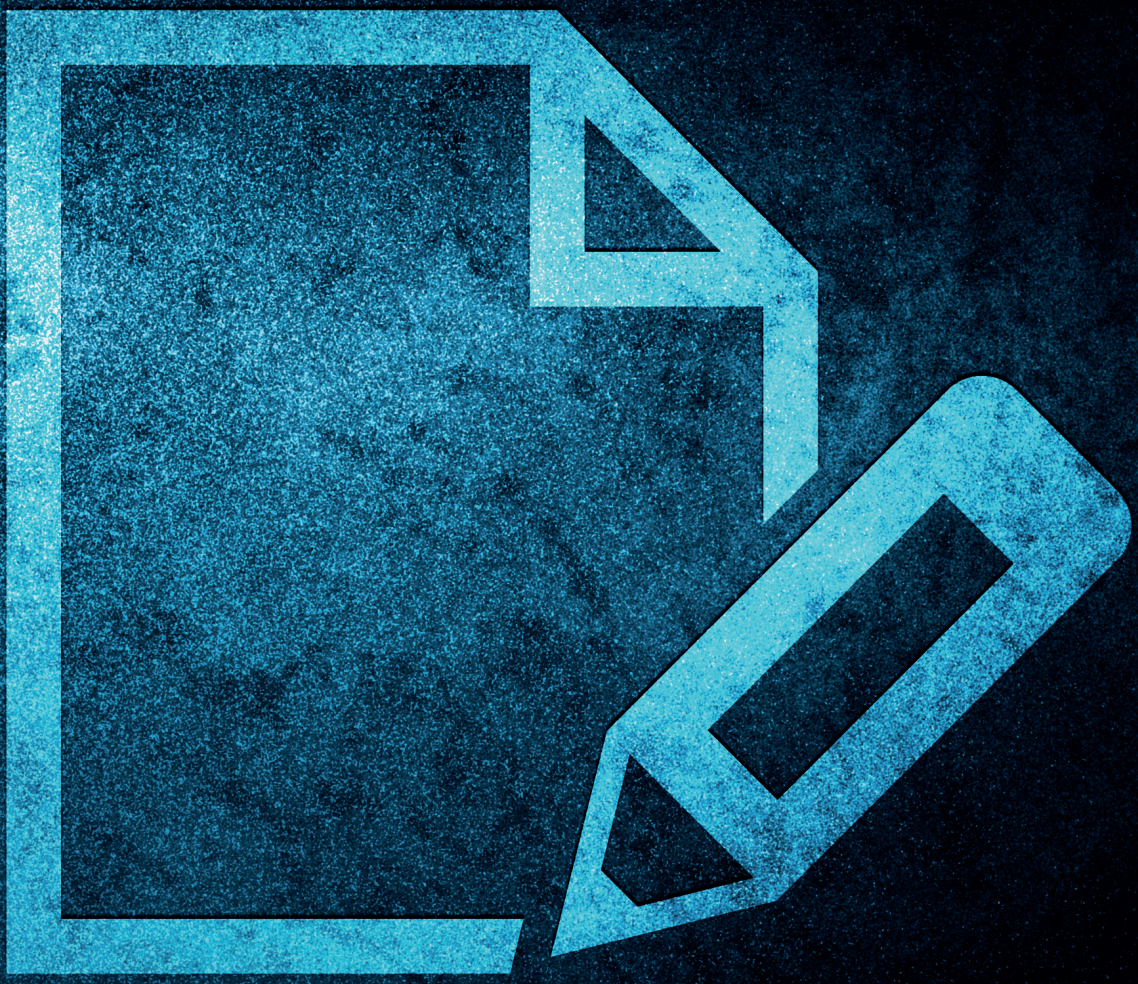

10th International Research Symposium on Problem-Based Learning:

ANCHORING CONVERSATIONS — WORK-IN-PROGRESS

Edited by Juebei Chen, Lelanie Smith, Yasmin Belal Abouarabi, Karin Wolff, Zachary Simpson, and Aida Guerra

ANCHORING CONVERSATIONS

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The role of educators' perceptions in the design and delivery of a sustainability module

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CONTEXT

Sustainability and sustainable development are complex concepts, with multiple interpretations from different perspectives. In engineering programs, they are often addressed through scientific and mathematical frameworks. Aspects such as renewable energy and resource efficiency are frequently emphasized, while the economic and social dimensions are often underexplored.

The Engineering Council of South Africa (ECSA) advocates for a broader approach to sustainability, encouraging engineering graduates to integrate technical, social, environmental, legal and ethical considerations into their designs and operations. South African engineering programs must advance towards a transformative, holistic approach that promotes technological innovation and practices that drive societal change, fostering environmental, economic, and social improvements as alluded by Daniels and Niemczyk (2023). This is essential to fulfilling the ECSA Graduate Attribute (GA) 7, which prepares engineers to evaluate the sustainability and impact of engineering activities on social, industrial, and physical environments (ECSA, 2020).

PURPOSE OR GOAL

Regard must be placed on the role of educators in designing, developing, and implementing curriculum. It is important to understand educators as stakeholders in the integration of sustainability education. The views of educators are important as they have the impact to determine how students learn and what they learn. As such educators' perceptions in teaching and learning affect what students learn (Olateru-Olagbegi, 2016; Ziegenfuss & Lawler, 2008). It is important to explore how educators' perceptions of sustainability will raise different sustainability values that will give students a holistic understanding of the complexity of sustainability.

The study aims to explore the relationship between engineering educators' perceptions of sustainability and the learning objectives of a sustainability module in a first-year mechanical engineering course at a South African institution. The objective of the ethnographic study is to investigate the curriculum design process of a sustainability module. The research aim is to answer how do perceptions influence learning objectives and outcomes.

APPROACH OR METHODOLOGY/METHODS

Using an ethnographic approach, the research involved observations, interviews, and document analysis, with Cultural-Historical Activity Theory (CHAT) applied to understand how educators' perceptions shaped the module's development.

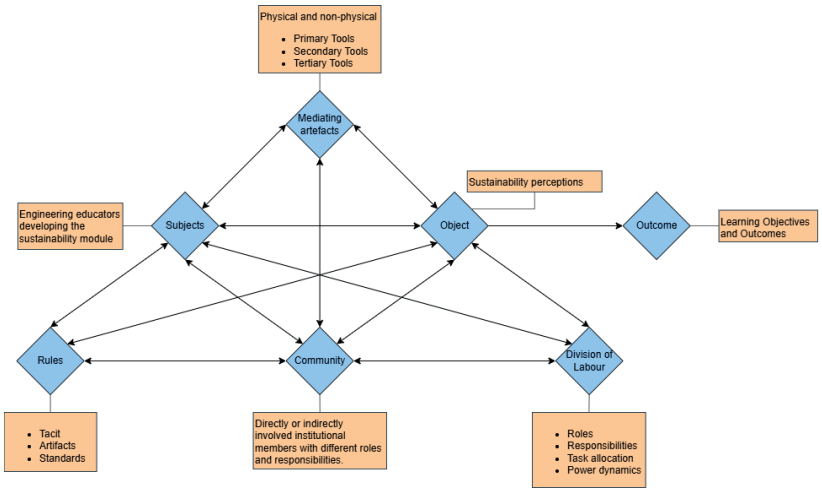

Figure 1: Modified Activity System Model from Engeström's Activity System (2005, p. 63)

Using the modified CHAT model shown in Figure 1, activity systems are used to describe the sustainability module development: one is the design of the module, and the other is the delivery of the module. The focus of this research makes the learning objectives and outcomes the outcome of the activity systems, which will frame how the other components of the activity system are defined. The subject (actors) in the activity systems are the educators who develop the learning objectives and outcomes. Their perceptions of sustainability impact what is viewed important for the students to learn in the sustainability module. Thus, the object of the activity systems are the sustainability perceptions of the educators. The sustainability perceptions determine the rules and tools used to produce the learning objectives and outcomes of the module. The community included various institutional members with different roles and responsibilities. The division of labour within the community is done to achieve the objective and outcome of the activity system. They are the roles and responsibilities taken by different members who are directly or indirectly involved in the activity systems.

ACTUAL OR ANTICIPATED OUTCOMES

The preliminary findings show that perceptions shape curriculum decisions in what tools and rules are chosen to develop the learning objective and outcome. Educators exercise this privilege due to their role as the framers of what students learn. From the perceptions expressed in the educators' deliberation and teaching give the perspectives that is used to give the module a distinctive voice and point of view. The community and division of labour shows the curriculum designers were composed of multidisciplinary educators who are able to carry out the holistic approach towards sustainability.

Overall, the findings show that perceptions shape the decisions in what tools and rules are chosen to develop the learning objective and outcome. Educators exercise this privilege due to their role as the framers of what students learn. From the perceptions expressed, in the educators' deliberation and teaching they show the perspectives that is used to give the module a distinctive voice and point of view. The community and division of labour gives the curriculum designers to be composed of multidisciplinary educators who are able to carry out the holistic approach towards sustainability.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

Understanding how educators' perceptions shape sustainability learning objectives and outcome will reveal whether the broader approach outlined by ECSA is achieved. In evaluating the sustainability module developed, it aligns with ECSA GA7 of critical awareness of sustainability. As the module is the introduction to sustainability in the mechanical engineering programme, it starts of by placing value to the concept which allows for deeper critic and knowledge over the years as the critical thinking of the students develops.

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KEYWORDS

sustainability, perceptions of educators, learning objectives, learning outcomes

Applying Deductive Thematic Analysis to Explore Resilience in South African Engineering Students: A Practical Guide

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CONTEXT

Resilience is a timely and important topic in student development, particularly within higher education. Although thematic analysis is frequently used to investigate learning processes and institutional structures, there remains limited guidance on how to systematically conduct and report Deductive Thematic Analysis (DTA) in educational research (Nowell et al., 2017). This paper addresses that gap by offering a step-by-step guide to applying DTA. The procedures presented are informed by the first author's master's research project (Mostert, 2025), which examined resilience among engineering students at a South African university of technology.

PURPOSE OR GOAL

The aim of this presentation is to illustrate how deductive thematic analysis process can be applied to understand resilience in engineering students. We describe the process from identifying theoretical constructs (e.g., socio-ecological factors), through generating codes and themes, to interpreting the findings.

APPROACH OR METHODOLOGY/METHODS

The study drew on semi-structured interviews with seven engineering students. Interviews were transcribed verbatim, capturing not only words but also tonal nuances. Data analysis followed Braun and Clarke's (2006, 2022) six-step thematic analysis process, adapted for a deductive approach. Ungar's socio-ecological model of resilience provided the coding framework, with four predefined levels: micro, meso, exo, and macro. Coding was conducted in NVivo, beginning with these categories while also allowing inductive insights (such as "load shedding stress") to enrich the analysis. Reflexivity was maintained throughout, with the researcher recording personal reflections and explicitly noting how context-specific factors intersected with the theoretical categories. The iterative process of coding, theme development, refinement, and final synthesis ensured that the final thematic map reflected both theory and the nuanced South African context.

ACTUAL OR ANTICIPATED OUTCOMES

The deductive thematic analysis produced nine interconnected themes: family influence, peer relationships and social support, academic environment and institutional support, personal coping and self-efficacy, health and well-being, institutional policies and resources, socioeconomic challenges and motivations, cultural and community influences, and role models or mentorship. These themes aligned coherently with Ungar's (2012) socio-ecological model, while also highlighting context-specific stressors such as load shedding, financial hardship, and cultural expectations. Students described resilience as a dynamic capacity shaped by both enabling resources (such as scholarships and peer networks) and constraining barriers (such as systemic inequality and institutional shortcomings), with ecological levels often intersecting in complex ways. Importantly, the analysis also showed

how Deductive Thematic Analysis, when applied systematically, can capture both theoretical categories and localized realities, producing findings that are rigorous, transparent, and meaningful for understanding student persistence.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

By starting with Ungar's (2012) socio-ecological model, the analysis ensured that multiple contextual layers were systematically addressed, while reflexivity allowed for the recognition of unique South African realities. Compared to prior research that treats resilience as primarily individual, this study reinforces the view that it is relational and systemic. Methodologically, this contribution contributes a clear, step-by-step guide to DTA that early-career researchers can replicate or adapt to their own work. The findings recommend that educators and policymakers design interventions that support resilience at multiple levels, for example, strengthening peer and family networks, improving institutional resources, and addressing broader socio-economic constraints. The study demonstrates that resilience is best understood not as personal toughness but as a dynamic interplay of ecological factors, and that DTA provides a robust way to capture this complexity.

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KEYWORDS

Deductive thematic analysis (DTA), qualitative research, interviews

Scoping Literature Review: Engineering Logic

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ABSTRACT

The analysis and evaluation of thinking in engineering contexts require a refined vocabulary for reasoning and critical thinking (Niewoehner, 2006). Paul and Elder's *Thinker's Guide to Engineering Reasoning* (2006) provides such a framework, adapting critical thinking specifically for the engineering discipline. This scoping literature review explores how engineering logic, defined as the structured use of critical thinking and reasoning in engineering design and decision-making, can be integrated into engineering education through a Problem-Based Learning (PBL) lens. As Serna (2015) notes, cultivating logical reasoning in engineering students enhances their problem-solving abilities and decision-making in complex contexts. This paper synthesizes key models (Paul & Elder, Hernandez, Summers) and discusses challenges and strategies for embedding engineering logic in curricula, particularly via active, PBL-oriented pedagogy.

INTRODUCTION AND SCOPE

The development of effective engineers hinges not only on technical knowledge but also on the ability to think critically and reason logically. Engineering practice involves complex problem-solving under constraints, uncertainty, and incomplete information. Paul and Elder (2006) emphasized that critical thinking is fundamental to engineering, enabling practitioners to assess arguments, evaluate ideas, and navigate real world design challenges.

Engineering education increasingly recognizes the need for developing graduates who can think critically, reason logically, and solve complex problems. However, many curricula emphasize technical knowledge at the expense of explicitly developing these cognitive capabilities. *Engineering logic* – the term used to describe the structured application of reasoning to engineering problems – offers a valuable lens through which to embed critical thinking into engineering pedagogy (Paul & Elder, 2006; Klimenko, 2007).

Problem-Based Learning (PBL) provides a natural content for this integration. PBL places students in real-world scenarios where they must identify problems, gather data, and generate solutions. Yet, the process of reasoning often remains implicit. Students may arrive at technically correct answers without understanding or articulating the reasoning behind their decisions. This paper reviews conceptual literature on engineering logic and outlines an implementation strategy to explicitly embed reasoning frameworks within PBL modules.

METHODOLOGY

This review follows a **scoping literature review** methodology based on Arksey and O'Malley (2005) to map key concepts and reasoning models relevant to engineering education and PBL.

1. **Objectives**

- Identify and categorise frameworks of engineering logic/reasoning.
- Analyse how such frameworks align with PBL pedagogy.

- Propose a practical application model for teaching engineering logic.

2. **Search Strategy**

- **Databases searched:** Scopus, IEEE Xplore, ScienceDirect, ResearchGate
- **Data range:** 2000 – 2024
- **Keywords used:** "engineering logic," "critical thinking in engineering," "engineering reasoning," "PBL in engineering"
- **Inclusion criteria:** Peer-reviewed sources on engineering logic, frameworks used in education or professional contexts.
- **Exclusion criteria:** Opinion-based texts without conceptual frameworks, non-engineering disciplines.

3. **Screening Process**

From an initial pool of 138 sources, 32 were retained for full-text review based on thematic relevance. Literature was coded thematically, aligning to four domains: (1) quality of student thinking, (2) critical thinking, (3) logical reasoning, and (4) engineering logic frameworks (see Table 1).

4. **Limitations:**

This is a conceptual synthesis; no empirical data was collected. However, to enhance relevance, preliminary findings were reviewed by a panel of three engineering educators with experience in PBL and curriculum design. Their input informed the thematic refinement of the review.

LITERATURE THEMES

The literature forming part of the scoping literature review is presented in four thematic clusters (Table 1), followed by an integrated synthesis focused on engineering logic as part of this paper.

TABLE 1: THEMATIC CLUSTERING OF REVIEWED LITERATURE

Section #	Theme	No. of Citations
1	Quality of Thinking and Reasoning in Engineering	6
2	Critical Thinking in Engineering Education	8
3	Logical Reasoning Approaches	8
4	Engineering Logic / Reasoning Frameworks	10

KEY FRAMEWORKS IN ENGINEERING LOGIC

The key frameworks in Engineering Logic are broken into three sections addressing the models included as part of the scope of literature reviewed, including: (1) Paul & Elder's Critical Thinking Model which provides the basis from which engineering logic / reasoning is contextualised; (2) Hernandez's Reasoning Taxonomy from which the main reasoning types are introduced around engineering logic; and (3) Retroduction (or retroductive reasoning) as initially introduced by Summers (2005), which provides a cyclical process of retroduction and reflection required as part of the engineering logic process.

1. Paul & Elder's Critical Thinking Model

While critical thinking and logical reasoning are often used interchangeably, engineering logic refers to the contextualised application of structured reasoning within engineering problem-solving. Paul and Elder's (2006) model articulates this through elements such as purpose,

assumptions, implications, and point of view tools that help engineers analyse their though process.

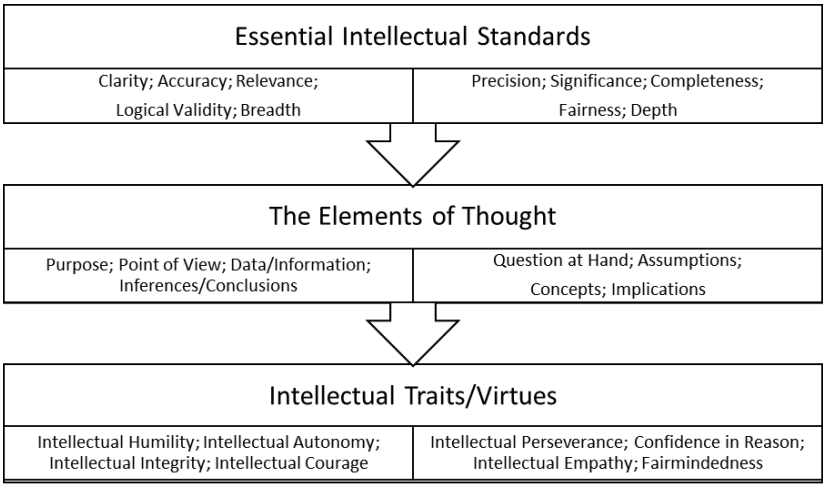

FIGURE 1: RICHARD PAUL'S CRITICAL THINKING MODEL (PAUL AND ELDER, 2003)

This transitions naturally into frameworks that describe specific **modes of reasoning** engineers use in complex design tasks.

2. Hernandez's Reasoning Taxonomy

Hernandez (2018) identifies three main reasoning types in engineering:

- Deductive reasoning: applying known rules to derive specifications.
- Inductive thinking: generating general principles from specific observations.
- Abductive logic: hypothesizing unknown design variables.

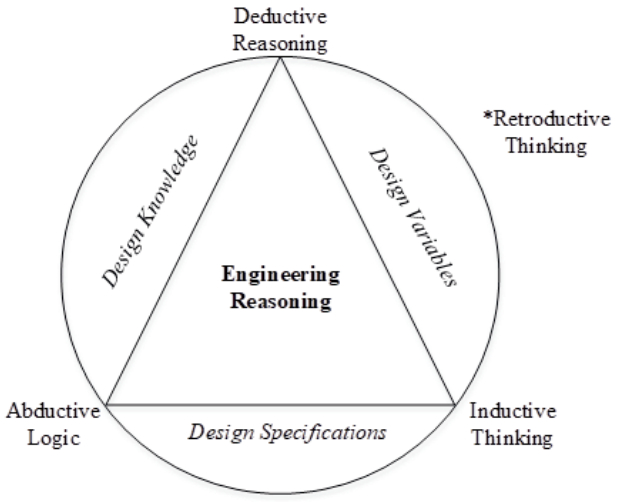

FIGURE 2: TYPES OF REASONING FORMING PART OF ENGINEERING REASONING, ACCORDING TO HERNANDEZ (2018)

These forms of reasoning align well with the non-linear, iterative nature of PBL. Students in PBL scenarios often engage in abductive logic without explicit awareness-hypothesizing causes or variables based on incomplete data.

3. Retroduction in Engineering

Summers (2005) introduces retroduction (or retroductive reasoning), which plays a role in discovering novel system parameters or constraints. This thinking mode is essential in open-

ended PBL tasks where students are encouraged to define and redefine the problem space iteratively.

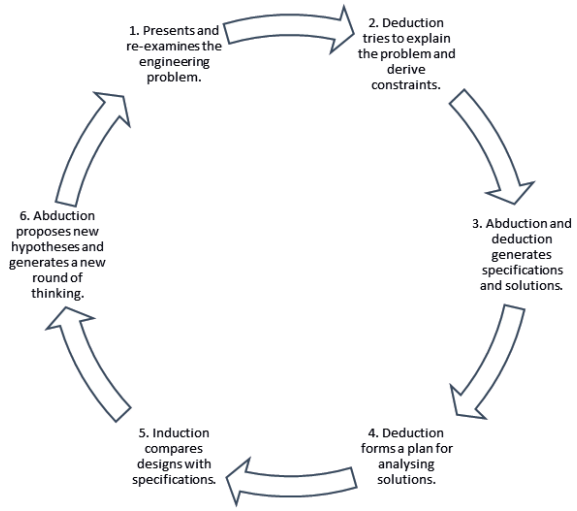

FIGURE 3: RETRODUCTIVE THINKING OR RETRODUCTION MODEL (HERNANDEZ, 2018)

REVIEW AND EDUCATIONAL IMPLICATIONS

1. The Role of Engineering Logic in PBL

Engineering logic serves as the cognitive engine that drives problem-solving in PBL environments. Rather than prescribing steps, it equips students with thinking habits and heuristics necessary to navigate ambiguity, evaluate trade-offs, and reflect on decisions.

Paul and Elder's framework, when explicitly taught, offers a vocabulary and scaffold for thinking – a contrast to PBL models that assume reasoning will develop implicitly.

2. The Challenges in Teaching Engineering Logic

Despite its importance, the integration of engineering logic into engineering education has been met with several challenges. Traditionally, engineering curricula have focused heavily on technical skills, such as mathematics, physics, and design principles, while often neglecting the development of critical thinking and logical reasoning skills. This approach has led to the assumption that students will naturally develop these skills through practice in real-world contexts (Serna, 2015). However, research has shown that students often struggle with the complexities of reasoning and decision-making, particularly when faced with ambiguous or ill-structured problems that are common in engineering.

One of the key challenges in teaching engineering logic is that it requires a shift in how engineering is taught. Instead of merely delivering technical knowledge, educators must also teach students how to reason through complex problems, evaluate potential solutions, and make decisions based on a variety of factors, including ethical considerations, resource constraints, and uncertainty. This shift necessitates the incorporation of critical thinking into every aspect of the engineering curriculum, which can be difficult for instructors who are accustomed to focusing on content delivery rather than process-oriented learning.

Summary of key challenges:

- Lack of formal instruction in reasoning frameworks.
- Faculty unfamiliarity with how to teach thinking processes.
- Curriculum overload with technical content.

Moreover, engineering logic is not a set of easily teachable skills; it involves the development of intellectual virtues (Paul & Elder, 2006). These virtues are cultivated over time and require continuous practice and self-reflection. Therefore, effective instruction in engineering logic must not only focus on teaching logical structures, but also foster an environment where students are encouraged to engage in metacognitive reflection about their thinking processes.

3. Best Practices in Teaching Engineering Logic

Despite these challenges, there are several strategies that have been identified as effective in promoting the development of engineering logic in students. One promising approach is the integration of active learning techniques into engineering courses. Active learning, which involves engaging students in the learning process through activities such as group discussions, case studies, and problem-solving tasks, has been shown to enhance students' critical thinking skills and foster deeper understanding (Prince, 2004).

Problem-based learning (PBL) is another effective strategy for teaching engineering logic. PBL involves presenting students with real-world problems that do not have clear-cut solutions. In this context, students must apply logical reasoning to analyse the problem, identify relevant information, generate possible solutions, and evaluate the consequences of different choices. PBL encourages students to engage in critical thinking and decision-making, and has been shown to improve students' ability to apply theoretical knowledge to practical solutions (Barrows, 1996).

The use of modern tools, such as computer simulations and data analysis software, can also support the development of engineering logic. These tools allow students to model complex systems, explore different scenarios, and visualise the results of their decisions, providing valuable feedback that helps refine their reasoning skills. In this way, technology can serve as both a teaching aid and a means of promoting deeper understanding of engineering principles.

Summary of effective integration strategies:

- Embedding **active learning** and **thinking routines** (e.g. Socratic questioning)
- Adopting **explicit reasoning models** in PBL modules.
- Using **case-based instructions** that highlights reasoning paths, not just final solutions.
- Leveraging **technology** (e.g. simulations, modelling tools) that offer feedback on decision outcomes.

A potential pedagogical strategy includes:

a) Introduce students to Paul & Elder's model as a metacognitive tool.
b) Introduce reasoning types via guided tutorials (Hernandez's Taxonomy).
c) Facilitating group reflections facilitated using "reasoning logs" where students document logic used in their decisions.
d) Assessing reasoning pathways evaluated through peer-reviewed design reports.

CONCLUSION

Engineering logic plays a critical role in the practice of engineering, providing the foundation for sound decision-making, problem-solving, and innovation. As the complexity of engineering problems continues to grow, the need for engineers to develop strong critical thinking and reasoning skills become even more important. By integrating models such as the Thinker's Guide to Engineering Reasoning into engineering curricula, educators can help students develop the intellectual virtues necessary for effective engineering practice.

However, challenges remain in effectively teaching engineering logic. Traditional engineering education has often overlooked the development of critical thinking skills, and students may not naturally acquire these skills without deliberate instruction. By incorporating active learning strategies, problem-based learning, and modern tools into engineering education, instructors can better support the development of engineering logic and prepare students for the complex and dynamic nature of the engineering profession.

As highlighted in the literature review, the ability to think critically and reason logically is essential for engineers to make informed decisions and solve problems efficiently. Moving forward, a greater emphasis on engineering logic in engineering education will help students navigate the challenges of the profession and contribute to the advancement of engineering as a discipline.

This paper argues that teaching engineering logic explicitly can strengthen the learning impact of PBL in engineering education. While the review is primarily conceptual, it serves as a guide for educators seeking to embed structured reasoning into their modules. The synthesis of Paul & Elder, Hernandez, and Summers' models offers a multidimensional toolkit for engineering instructors.

Although this review did not develop a new model, it contributes by synthesising reasoning frameworks under a PBL lens, offering practical recommendations for curriculum design. Future works should explore empirical applications of this synthesis, potentially assessing its impact on student reasoning development in engineering education.

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KEYWORDS

Engineering Logic, Critical Thinking, Problem-Based Learning, Engineering Reasoning, Scoping Literature Review

Early Warning System with Targeted Interventions for an Undergraduate Program at a University of Technology

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ABSTRACT

Early Warning Systems (EWS) are essential for monitoring student advancement and enhancing success rates in higher education. EWS utilizes data-driven insights to identify at-risk pupils and deliver prompt interventions. Despite the piloting of programs such as AutoScholar in South Africa, apprehensions persist over their efficacy and durability. Universities of Technology (UoTs) encounter difficulties in addressing varied student needs, highlighting the necessity for cohesive academic and non-academic assistance. This project sought to develop and execute an Early Warning System at CPUT to improve retention in engineering. The system aimed to evaluate if interventions like mentorship, counseling, and reassessment could enhance outcomes, while simultaneously examining the efficacy of a data-driven, predictive methodology. The system required Lecturers to upload preliminary marks within ten days, identify students scoring below 50%, and perform interviews to ascertain causes. Interventions comprised recommendations for tutoring, mentorship, and counseling, accompanied by follow-ups following subsequent evaluations. Results indicate an increase in pass rates from 69% in 2022 to 81% in 2024. Results affirm that academic and socio-economic difficulties require a comprehensive approach. Recommendations encompass mentorship for all students, enhanced financial and psychological assistance, predictive analytics, and specialized academic seminars.

KEYWORDS

Early Warning System, Student Retention, Universities of Technology.

CONTEXT

Student success and attrition persist as primary challenges in higher education worldwide, with these issues being especially acute in South Africa. Since the end of apartheid, the nation's higher education system has markedly broadened access, particularly with a large rise in the enrollment of historically marginalized students (Chiramba and Ndofirepi, 2023). This growth has not correspondingly resulted in enhanced retention or graduation rates. Research repeatedly indicates that South African institutions face elevated dropout rates, particularly during the initial years of undergraduate education. The Department of Higher Education and Training (DHET) has shown that less than 50% of students finish their degrees within the stipulated minimum duration, with approximately 55% graduating within six years (Khuluvhe et al., 2021). Attrition rates are most pronounced in the fields of science, engineering, and technology, where curricular demands frequently coincide with socioeconomic, cultural, and language obstacles (Letseka & Maile, 2008; Schreiber, 2012). These patterns not only indicate inefficiencies in the educational pipeline but also signify missed chances for social and economic transformation in a nation currently contending with inequality.

Student attrition in South Africa results from a combination of academic and non-academic challenges. Beyond academic preparedness, financial difficulties, food insecurity, housing shortages, and limited psychosocial support hinder student success (Adanyr, Abdieva & Muhametjanova, 2021). Universities of Technology (UoTs), which serve many first-generation and working-class students, are particularly vulnerable. Traditional approaches, such as remedial courses and ad hoc tutoring, have proven insufficient. Instead, institutions require a systematic, proactive strategy that identifies at-risk students early and delivers tailored interventions addressing both academic and socio-economic factors.

Early Warning Systems (EWS) offer such a strategy. These frameworks monitor student performance to detect risks of dropout and trigger timely support (De Klerk, 2023). Global models vary, from predictive analytics in North America to tutor-led systems in Europe and Asia, but share the principle that disengagement precedes withdrawal and can be countered with intervention (Imundo et al., 2025).

PURPOSE

Research shows EWS not only improve performance but also strengthen belonging and engagement (Arnold & Pistilli, 2012; Fook & Sidhu, 2015). In South Africa, however, implementation remains uneven. Many systems focus narrowly on grades or attendance, overlooking the socio-economic hardships that weigh heavily on UoT students (Mayet, 2016; Schreiber, 2012). Thus, comprehensive, context-specific EWS models remain urgently needed. This is the purpose of this paper.

METHODOLOGY

This study applied Design-Based Research (DBR), an iterative and collaborative methodology integrating design, implementation, and refinement to develop context-specific educational interventions (Wang & Hannafin, 2005). DBR emphasized ecological validity (Anderson & Shattuck, 2012), enabling the creation of an Early Warning System tailored to the University of Technology's challenges.

This study in CPUT's Chemical Engineering Department examined at-risk students, those scoring below 50% early, with financial or psychosocial challenges (Schreiber, 2012). Using lecturer input and interviews, tailored interventions supported first-generation, working-class, and marginalized cohorts.

The Early Warning System (EWS), guided by DBR, unfolded in four phases. Phase 1 involved data entry of initial scores into an Excel template, flagging underperforming students (<50%) for early support. Phase 2 used semi-structured interviews to uncover academic, socio-economic, and psychosocial barriers. Phase 3 referred students to tutoring, counseling, or financial aid. Phase 4 tracked progress through mid- and end-semester assessments, followed by reflective interviews and departmental reporting.

Instruments included Excel templates, interview protocols, and evaluation forms, enabling data collection, monitoring, and iterative refinement under DBR.

Ethical safeguards included informed consent, confidentiality, non-maleficence, and equitable access, with CPUT ethics approval ensuring respectful, supportive student interventions.)

ACTUAL OUTCOMES

The introduction of the Early Warning System (EWS) in the Department of Chemical Engineering at the Cape Peninsula University of Technology (CPUT) produced measurable

improvements in student outcomes across three cohorts (2022–2024). The findings reveal both quantitative progress in pass rates and qualitative evidence of strengthened student engagement, belonging, and resilience. Student pass rates rose consistently: 69% in 2022, 76% in 2023, and 81% in 2024. This 12-point increase demonstrates the impact of timely, targeted interventions. These results confirm international and local studies showing that Early Warning Systems, when combined with psychosocial and academic support, can significantly enhance retention (Arnold & Pistilli, 2012; Mayet, 2016). The EWS combined academic and non-academic strategies. Targeted tutoring addressed courses where students struggled most, with regular participation linked to marked performance improvements (Mayet, 2016). A mentorship program paired senior and junior students, creating peer networks that improved adjustment, belonging, and persistence, echoing research on the power of engagement (Astin, 2014; Chrysikos et al., 2017). Referrals to counseling services helped students cope with anxiety and stress, aligning with literature that highlights mental health as central to retention (Thomas, 2012; Schreiber, 2012). Socio-economic support was equally vital: referrals to bursaries, food support, or housing services alleviated immediate pressures, reinforcing equity of access. The EWS proved successful due to three key strengths. First, timeliness: students were identified within the first 4–6 weeks, allowing proactive responses. Second, personalization: interviews and tailored referrals addressed the diverse realities of students' academic, financial, and psychosocial lives. Third, integration: the program connected academic tutoring with counseling and socio-economic support, reflecting the multifaceted barriers in South African higher education (Fook & Sidhu, 2015; Mayet, 2016). Together, these created a holistic safety net for students. Challenges, however, persisted. Limited resources constrained aid services. Some students were reluctant to participate due to stigma, while lecturers reported the administrative burden of uploading marks and conducting follow-ups. These issues mirror wider concerns about the sustainability of Early Warning Systems in resource-limited contexts.

The CPUT case validates the efficacy of EWS in a University of Technology environment. Pass rates improved, but equally important were gains in belonging, confidence, and accountability. These findings align with global evidence, including Purdue's Course Signals program in the US (Arnold & Pistilli, 2012) and the UK's What Works? initiative (Thomas, 2012), while addressing African contexts shaped by inequality (Letseka & Maile, 2008). The CPUT model also reflects Tinto's integration theory and Astin's engagement model, demonstrating how peer mentoring and continuous reflection drive persistence. Sustainability requires institutional commitment. Staff workload must be reduced through predictive analytics, while still balancing automation with contextual sensitivity (Long & Siemens, 2014; Nnadozie et al., 2023). Equally, policies should enshrine student support as central to pedagogy, ensuring counseling, financial aid, and mentoring are treated as essential. Ultimately, EWS must be judged not only by throughput gains but by their capacity to foster inclusive, supportive environments. At CPUT, the system advanced both academic success and the broader goals of equity and transformation in higher education.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

This research demonstrates that comprehensive implementation of Early Warning Systems (EWS) can markedly improve student success in South African Universities of Technology (UoTs). The Department of Chemical Engineering at CPUT implemented a multi-stage Early Warning System (EWS) utilizing a design-based research (DBR) framework, which incorporated academic monitoring, personal interviews, referrals, and ongoing follow-up.

The system produced three significant contributions. Initially, it enhanced academic performance, as pass rates increased from 69% in 2022 to 81% in 2024, illustrating that

prompt identification and intervention can alter failure trajectories. Secondly, it considered both academic and non-academic concerns, including financial difficulties, housing, language barriers, and psychosocial issues, recognizing the comprehensive nature of student persistence. Third, it enhanced theory and practice by demonstrating how Design-Based Research (DBR) can inform contextually pertinent interventions that correspond with institutional realities. These findings collectively underscore the necessity of integrating Early Warning Systems at the departmental level to enhance throughput, equity, and change.

Practical Recommendations

1. Universal Mentorship: Enhance peer-mentorship by pairing each first-year student with a senior mentor, thereby normalizing the act of requesting assistance and offering preventative support instead of corrective intervention.

2. Integrated Support Systems: Establish cohesive collaboration among faculties, counseling, financial assistance, and housing via a centralized student success hub.

3. Predictive Analytics: Integrate automated dashboards to monitor engagement and performance, ensuring a balance between efficiency and human-centered intervention.

4. Staff Development: Facilitate professional training for educators to analyze EWS data, conduct supportive interviews, and integrate student support into pedagogical practices.

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Teaching a doing thing - relatability factors influencing teaching honours level research

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CONTEXT

The honours qualification is critical for students professionally and for their articulation academically in research. In South Africa's higher education system, the national qualification framework (NQF) outlines the purpose of the honours year of study (B Hons) as NQF level 8, which usually follows a bachelor's degree (NQF level 7) and is the minimum entry requirement for masters (NQF level 9). The Higher Education Qualifications Sub-Framework (HEQSF) 2013 stipulates that B Hons comprises a minimum of 120 credits, and at least 30 credits (i.e., 25% of the qualification) must involve research, in addition to the coursework component. The research component takes place under supervision as it teaches students discipline-specific research methods principles and dissemination or communication of the findings. Because of the significant 25% weight of the research component for the honours qualification, it is critical to evaluate the pedagogical factors, especially that of relatability i.e. the degree of familiarity between academics and students in relation to their backgrounds, experiences, identities, and cultures (see Sitto-Kaunda, Moroeng & Makhubela, 2023) on the student experience of being taught research. Teaching research at honours level takes different forms across disciplines. These range from taught research modules focused on instilling the principles of research to supervisor-led learning of how to conduct research, through pragmatic pedagogy to become intellectually independent researchers in their communities of practice. Pragmatism is a teaching philosophy centred on linking theory, research and activities to practical applications, and involves multiple stakeholders and perspectives to develop students' critical thinking through self-discovery (Klockner, Shields, Pillay & Ames, 2021). Research is a pragmatic subject, that needs to be taught through doing, to deepen students' disciplinary expertise and enable their success. There is often an assumption that the students' understanding of research principles is correlated to the experience of the instructors and supervisors, with limited examination of the influence of instructors' supervision-based teaching methods in how students approach learning while doing research.

PURPOSE OR GOAL

We consider the significance of the honours degree, as students' first introduction to formal academic research culminating in a research output and developing many soft skills such as communication. The purpose of this paper is to highlight the pedagogical factors, especially that of relatability, in influencing students' experience of discipline-specific research. We focus on the significance of the role of supervisors-as-teachers during honours in how students learn to conduct research pragmatically, based on how it is taught in the social sciences and the natural sciences; and some of the key relatability factors for consideration in research pedagogy at the honours level. The readiness of honours students includes four key elements, namely the research environment, self-efficacy, orientation, and a student's learning motivation (Shaw & Holbrook, 2006) with their sense of belonging depending significantly on their relatability to those teaching, mentoring and supervising them. The main objective of our paper is to evaluate the teaching and learning approaches to honours research of natural and

social sciences disciplines in preparing students for professional and post graduate research progression. The secondary objective of our paper is to underscore the role of relatability (Sitto-Kaunda, Moroeng & Makhubela, 2023) between honours student and supervisor-as-teacher in the different ways that research pedagogy is approached in the honours degree. The paper deals with the following research questions:

1. What role does the disciplinary design of teaching honours research play in developing the student's readiness as a post graduate researcher?
2. How does supervisor relatability influence the pedagogical outcomes of honours students in preparing them for research-based postgraduate study progression?

APPROACH OR METHODOLOGY/METHODS

Using a qualitative approach, narrative design will be undertaken to capture the authors' experiences in honours research pedagogy over the period of 2021 – 2025 as coordinators and supervisors, considering ourselves as participant-observers. We held several meetings to explain and discuss the similarities as well as differences across our disciplines in teaching research to honours students. In addition to our personal narratives, we support these with our professional critical interdisciplinary pedagogical observations, discipline-specific programme materials and direct correspondence from student and colleagues to develop key themes. The data collated was analysed to develop key insights on how the design influences the readiness of honours students, and the influence of the supervision relationship, specifically relatability, on student outcomes in becoming independent researchers in their disciplines.

ACTUAL OR ANTICIPATED OUTCOMES

We observe that the research readiness of honours students is influenced by how the module/course, which weighs a quarter of the qualification, is designed within the discipline in training students in specific methodologies and to become independent researchers that can articulate/progress into the Masters level and beyond. Relatability in the student/supervisor relationship also plays a key role in how students experience conducting research, and their attitude towards it, beyond simply being competent researchers, as it provides a basis for common understanding between honours students and supervisors. Academics responsible for teaching research principles to students when approaching it from a pedagogy of care infuse it into how they setup their research coordination role, including the design of the student/supervisor relationship. Research coordinators often become informal research mentors to students because of their relatability and they rely heavily on the relationship between supervisors and students to ensure success at the honours research level.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

Research pedagogy takes a coordinated effort from multiple people and requires a good understanding through relatability to meet honours students where they are, especially because research is taught by doing i.e., it is pragmatic. The different disciplinary approaches to teaching research can result in unmet expectations, frustrations, confusion or complete research readiness, depending on how students are taught, facilitated through their relationships with supervisors.

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KEYWORDS

Honours research, research pedagogy, relatability, pragmatism, supervisor-as-teacher

Scaffolding Complexity in Structural Dynamics: A Digital Twin-Based PBL Intervention Using Legitimation Code Theory and Computational Thinking

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CONTEXT

Teaching structural dynamics and monitoring systems presents significant challenges due to their abstract nature and reliance on mathematical modelling. Students often struggle with formulating and solving ordinary differential equations (ODEs), understanding boundary conditions, and grasping concepts such as damping and system frequency. These difficulties are compounded by the hierarchical nature of engineering knowledge, which demands cumulative understanding across multiple conceptual layers (Bernstein, 1999). To address this, a Digital Twin-based Project-Based Learning (PBL) intervention was designed, integrating physical modelling, sensor-based data acquisition, and finite element simulation. This approach aligns with contemporary pedagogical models that emphasise experiential learning, semantic integration, and computational thinking (Wolff et al., 2022).

PURPOSE

This study investigates how a Digital Twin-based PBL approach can enhance conceptual understanding in structural dynamics. Specifically, it explores how students engage with abstract concepts through semantic waving and computational thinking, and how digital tools can scaffold complexity in engineering education. The intervention is framed by Legitimation Code Theory (LCT), which distinguishes between semantic gravity (context-dependence) and semantic density (complexity) (Maton, 2014), and by Bernstein's theory of vertical and horizontal discourse, which highlights the structured progression of specialised knowledge (Bernstein, 1999). The study also draws on Wolff et al. (2022), who emphasise the role of technology-supported learning in scaffolding complexity in engineering education.

METHODOLOGY

A Design-Based Research (DBR) methodology was employed to develop and evaluate the intervention. The study was conducted with a cohort of Honours-level civil engineering students at a university of technology in South Africa. Since 2022, iterative cycles of implementation, observation, and refinement have taken place, with student feedback collected across multiple academic years. Students constructed a cable-stayed bridge using Mola Structural Kits, embedded sensors (MPU6050) connected to Arduino Uno, and created a corresponding finite element model in Abaqus FE software. Sensor data was used to tune the FE model's mass and stiffness to match the physical model's natural frequencies. Damping was estimated using Rayleigh damping based on structural response data. Students then performed parametric analyses by introducing controlled perturbations and comparing simulated and experimental responses. Learning activities were mapped onto the semantic plane to visualise shifts in semantic gravity and density. Computational thinking principles—decomposition, pattern recognition, abstraction, and algorithm design—were embedded throughout the project workflow.

Semantic Plane Representation

To analyse the pedagogical impact of the intervention, learning activities were mapped onto a semantic plane based on the dimensions of Legitimation Code Theory. Figure 1 illustrates this semantic plane, showing how students moved between concrete and abstract representations (semantic gravity) and between simple and complex meanings (semantic density). The four quadrants represent distinct learning modalities: (I) physical modelling using Arduino and sensors (SG+, SD−), (II) graphical output of acceleration-time plots (SG−, SD−), (III) analytical and numerical modelling using Abaqus FE software and MATLAB (SG−, SD+), and (IV) illustration of real-word application of the Digital Twin and smart monitoring systems using sensors for the Clifton suspension bridge (SG+, SD+) (Pregnolato, et al, 2023). This semantic waving supports cumulative knowledge-building and conceptual integration (Blackie, 2014).

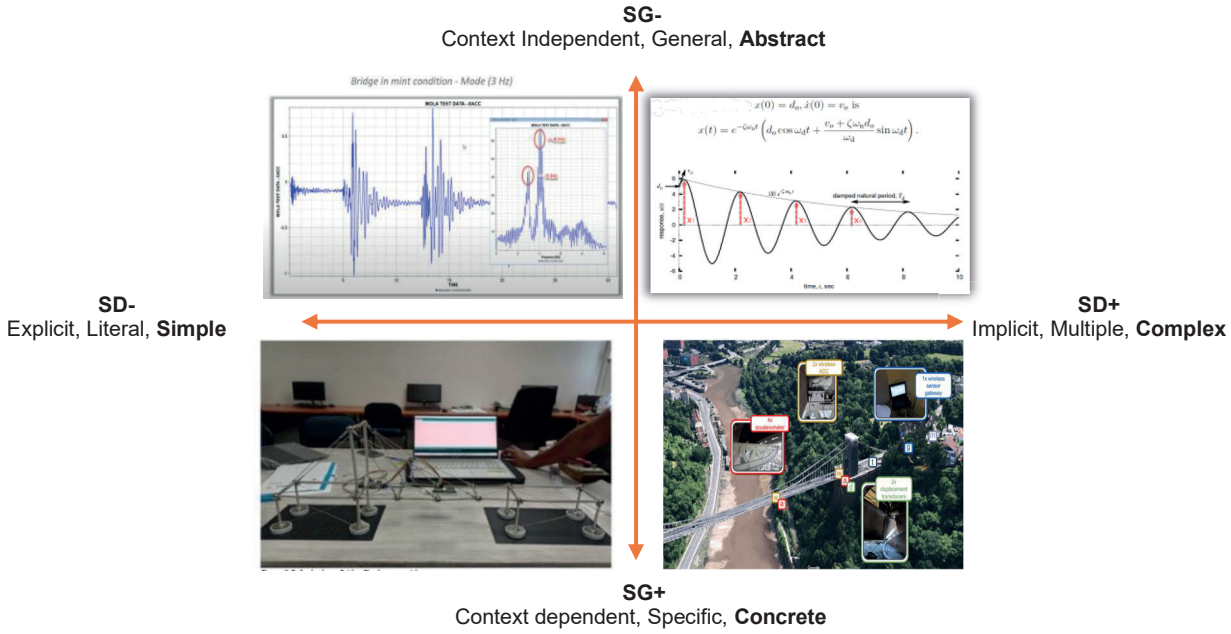

Figure 1. Semantic planes for teaching Dynamics of Structures and Monitoring Systems

OUTCOMES

Student feedback revealed enhanced understanding of structural dynamics, increased motivation, and improved problem-solving skills. Learners reported that the physical modelling experience made abstract concepts tangible and that working with sensors and simulations fostered deeper engagement. The semantic plane analysis showed effective semantic waving, enabling students to move between concrete and abstract representations (Maton, 2014). Computational thinking skills were developed through iterative modelling and simulation tasks. Students also expressed excitement about engaging with emerging technologies and recognised the relevance of Digital Twins in modern engineering practice.

CONCLUSIONS AND RECOMMENDATIONS

The study demonstrates that Digital Twin-based PBL can effectively scaffold complexity in structural dynamics education. By enabling semantic waving and integrating computational

thinking, the intervention supports cumulative knowledge-building and prepares students for data-driven engineering environments. Bernstein's theory of vertical discourse emphasises the importance of structured progression in specialised knowledge, while Maton's semantic wave model underscores the need for deliberate transitions between abstraction and context. These insights affirm the value of combining LCT and CT to design meaningful learning experiences in engineering education. Future work should explore the scalability of this approach across disciplines and its impact on long-term learning and professional readiness.

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KEYWORDS

Project-Based Learning, Digital Twin, Structural Dynamics, Legitimation Code Theory, Computational Thinking, Engineering Education

Co-Created and Community Owned Chatbots in PBL: Work-in-Progress

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CONTEXT

The arrival of generative artificial intelligence (GenAI) technologies in education is disrupting student learning experiences, with chatbots emerging as potential learning companions leading to speculations about both new affordances and challenges (Bozkurt et al., 2023). While general-purpose chatbots such as ChatGPT and CoPilot offer dialogic affordances that can be adapted to support teaching and learning, their lack of contextual precision and transparency limits their value in particular educational contexts. In problem-based learning (PBL) environments, where collaboration and self-regulated learning are central, there is a new opportunity to explore how creative applications of chatbots can support these pedagogical tenets. Prior research suggests that applications of AI tend to mirror dominant teaching and learning approaches, which remain largely teacher-centred, and knowledge focused (Xu & Ouyang, 2022). As a result, the application of AI in education has primarily focused on supporting individual and closed formats of learning rather than enhancing group dynamics and collaborative learning in more open formats, such as PBL (Otto et al., 2025; Septiani et al., 2023). In recent reviews of chatbot applications in education (Wollny et al., 2021; Hwang & Chang, 2023; Labadze et al., 2023) it is found that there is a need for better alignment between learning strategies and chatbot designs. The use of instructor-led, knowledge focused GenAI applications of general-purpose chatbots in learning environments that emphasize open, contextual and collaborative learning presents several challenges. These include inaccuracies or irrelevant responses in project specific contexts derived from overly general databases (e.g. general purpose chatbots or custom chatbots based on a fix, closed curriculum), a lack of transparency both in terms of undisclosed individual use in teams, and the 'black box' nature of proprietary chatbots, which are neither open-source nor fully transparent about their inner workings, potentially leading to hidden biases.

Given these challenges and the increasing presence of AI in education, this project explores the feasibility of co-created, community-owned chatbots designed to support project teamwork. By designing chatbots with such pedagogical intent, we can learn more about the affordances and challenges of GenAI applications in learning environments grounded in sociocultural and social constructivist theories.

PURPOSE OR GOAL

This study aims to investigate how democratic, co-creative chatbot design processes can support collaborative learning and knowledge construction in PBL courses at Aalborg University and the University of Cape Town by increasing transparency in terms of group practices and chatbot design. The project seeks to explore how collaborative chatbot customization influences learning behaviours and whether co-creation and shared ownership impacts trust in GenAI tools and trust between students. Key research questions include: (1) How do project teams design chatbots to support their own learning? (2) How do chatbot co-creation and shared ownership address issues of transparency in terms of collaborative practices and chatbot design? (3) What are the pedagogical implications of integrating dynamic, real-time learning chatbots in PBL environments from educators' perspective? By

addressing these questions, the study aims to contribute to the discourse on AI in education and entangled pedagogy (Fawns, 2022).

APPROACH OR METHODOLOGY/METHODS

A participatory co-creation workshop will serve as the foundation for chatbot development, where students and instructors collaboratively design a course bot before students create their own project bots. This iterative process invites collective reflections on AI integration with PBL-pedagogy, system prompt framing, data source identification, and ethical considerations. Data collection will include chatbot designs and logs. Thematic analysis will be applied to the data to analyse chatbot designs and interactions and lead to theoretical reflections on implications for future PBL pedagogy. Additionally, the study will examine ethical considerations related to shared chatbot ownership and co-creation. By adopting a participatory research framework, the project ensures that students actively contribute to shaping GenAI tools that align with their educational needs.

ACTUAL OR ANTICIPATED OUTCOMES

The anticipated outcomes of this study include better understanding of how GenAI can be used in collaborative learning environments while addressing issues of transparency in groups and in relation to chatbot design. Furthermore, students are expected to develop a deeper understanding of PBL principles and learning strategies through chatbot co-creation. The project also anticipates insights into what students value in their application of AI – and how to use this insight to inform development grounded in student values and needs. Findings may reveal new opportunities of working with GenAI in PBL environments and challenges related ethical concerns and data management and privacy, and disparities in AI tool availability and literacy. Additionally, the research may highlight strategies for ensuring chatbot adaptability to evolving student needs. If successful, the study could provide a scalable model for integrating co-created and community-owned chatbots across various educational settings, fostering more transparent, student-centred GenAI applications.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

By engaging students in chatbot design, the study promotes transparency, ownership, and pedagogical alignment, while mitigating issues of trust and transparency. The findings may inform future AI-driven educational strategies, emphasizing the importance of adaptability, inclusivity, and student agency. Further research should explore how such chatbots could support students across multiple projects and semesters and also address the needs of neurodivergent learners. Additionally, institutions should consider policies that ensure equitable access to advanced AI tools, preventing disparities in technological resources. The study contributes to the broader discourse on entangled pedagogy by demonstrating how technology, pedagogy, and student engagement intersect in dynamic active learning environments.

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KEYWORDS

Chatbots, Problem-based learning, Co-creation, Community owned, GenAI

Understanding Undergraduate Engineering Students' Academic Resilience Over a Full Year of Study

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KEYWORDS

Engineering Student Stories, Academic Resilience, Interpretative Phenomenological Analysis.

CONTEXT

Undergraduate engineering students can experience various challenges with studying at university (Jensen et al., 2023). Sources of adversity exist at multiple levels (sometimes illustrated using the Bioecological Model of Human Development by Bronfenbrenner & Morris, 2006) and can have varying impacts on the students' ability to study. Students' overcoming of such adversities is known as Academic Resilience (AR) (Martin & Marsh, 2006).

Research on students' AR and related concepts often focuses on improving student retention (Carnell et al., 2018; Moreno-Hernandez & Mondisa, 2021). To date, various university-based interventions have been trialled to enhance students' resilience, such as investigating improvements to students' responses to stressors (Brewer et al., 2019). In contrast, this project hopes to inform systemic changes which reduce the impact of challenges on engineering students throughout studying. To do this, how students make sense of and face challenges across one academic year is being explored.

PURPOSE OR GOAL

The research questions for this study are: "How do individual undergraduate engineering students make sense of academic challenges?" and "What differences may occur in responses to challenges between the first and final year of their course?". Implicit in these questions is the identification of what "challenges" are perceived and faced by each student.

APPROACH OR METHODOLOGY/METHODS

Longitudinal, semi-structured interviews were used to collect data with six undergraduate engineering student participants. Each participant attended two or three rounds of one-to-one interviews per their availability. Interview recordings were automatically transcribed, corrected by hand to represent the speech verbatim, then my interpretations of tone and meaning to satisfy the hermeneutic rigour for Interpretative Phenomenological Analysis (IPA) (Smith et al., 2022; Riessman, 1993).

IPA is applied to the 16 interviews "...to know in detail what the experience for (each participant) is like" (Smith et al., 2022), aligning with the perspective that approaches to adversities can be individualised in magnitude and effect (Luthar et al., 2000). Smith et al. (2022) recommend "between six and ten" interviews per study to enhance focus and enable deep analysis of each interview, but a larger volume of data has been deemed suitable for this study using the guidance of Pietkiewicz & Smith (2014). This is to both detail individual cases (themes for each interview) and note how the perspectives of students change across the academic year in response to adversities; a key feature of AR (Cassidy, 2016).

ACTUAL OR ANTICIPATED OUTCOMES

As of August 2025, Personal Experiential Themes (PETs) have emerged from the final interview of one first-year participant. Her seven PETs describe her personal experiences of the course, like: "Her

enjoyment of the course is based on how learning and work feels to her, including in relation to other aspects of living" and "(She) emphasises her attitudes towards learning and other events using figurative language, or by making comparisons".

I expect to present PETs from three participants' interviews at the IRSPBL conference. Based on a preliminary study and my current familiarity with each participants' responses across the academic year, it seems likely that these themes will feature expectation-setting, with first-year students' expectations changing more between the first and last interview than the final-years' due to the former group adjusting to a new university setting throughout the study (Andrews et al., 2019).

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

Already some PETs reflect existing knowledge of how students navigate academic challenges. For example, one of the mentioned participant's themes describes her use of supportive peer relationships (Kwarikunda et al., 2023) "(by valuing) her peers' influence; she sets expectations and reflects on how she should act using peers' behaviour and advice". The data are expected to provide rich descriptions of students' AR, assisting in effectively examining and removing systemic challenges posed to them.

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Leveraging problem-based learning for sustainability transitions – insights from two professional courses

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The abstract has not been update by September 2025. This is scheduled when the data collection has been completed by the end of October.

CONTEXT

The educational phenomenon under examination is how problem-based learning (Holgaard, 2021) principles and activities in two professional courses enable "translation into" and "changes of" the participants' professional work practices within the context of sustainability transitions in growth and developing countries.

The problem-based learning principles and activities are examined in two 3-weeks courses offered by the Danish government institution, Danida Fellowship Centre. The courses are offered to partners supported by the Danish Development Cooperation in growth and developing countries. These partners are engaged in a partnership project with a Danish counterpart organisation.

Both courses are 3-weeks long, residential in Denmark, and inspired by problem-based learning and experiential learning methods. The Responsive Project Management course focuses on specific tools and concludes with an individual project and action plan. The other course on Green and Circular Economy, is a broader and thematic course where the participants develop a shared country project and action plan.

The participants in these courses come from different countries and represent public, private and civil society organisations involved in various change projects related to sustainability transitions (health, water, energy, waste and food)

PURPOSE

The study is part of an Industrial PhD project conducted in collaboration with Aalborg University and Danida Fellowship Centre (DFC). The purpose of the study is twofold. The academic goal is to contribute to the academic research on problem-based learning in a professional context. The study aims to deepen the understanding of how problem-based learning principles and activities from an education context can be effectively and meaningfully applied in a professional learning context, particularly in the realm of sustainability transition. The practice goal is to enhance the courses offered by DFC to partners supported by the Danish Development Cooperation in growth and developing countries. By examining the effectiveness of problem-based learning principles and activities, this study seeks to provide actionable recommendations for improving the design and delivery of these courses.

The preliminary research question guiding this study is *how problem-based learning enable translation into and changes of the participants' professional work practices*?

The objective is to explore how the overall learning design, and the problem-based learning principles in particular enable and facilitate for changes in the participants professional work practices in their home organisations.

APPROACH OR METHODOLOGY/METHODS

The overall methodology is educational design research (McKenney & Reeves, 2018). The study is currently in the "explore and analysis phase", which aims to contribute with recommendations to the subsequent "design and construction phase".

Ethnographic methods are employed. Observations will be made at the two courses to identify when and where the participants translate the course content into their own contexts and how the problem-based learning activities supports this process. Document review of the course descriptions, course materials, participant applications and learning products such as case projects and action plans will be conducted. The two course managers are interviewed and 15 out of the 47 participants from 14 countries are interviewed before, during and 5 months after the course for in-depth exploration of changes in the participants practices. Lastly 5-6 of these participants supervisors are also interviewed. The 15 participants organisations are partnering with the Danish Environmental Protection Agency as counterpart on Strategic Sector Cooperations projects focusing on waste management and circularity in Kenya (7) and Indonesia (8). The two courses and 15 participants have been purposeful selected to ensure a high number of interviewees from similar countries and transition contexts and to analyse two different problem-based learning practices and course types.

The interview method employs a visual mapping technique inspired by situational analysis (Clarke et al., 2022) and social learning theory (Wenger-Trayner & Wenger-Trayner, 2021). During a facilitated process, participants develop a visual representation of their work context, including connections between actors, strength of ties, areas of challenges and opportunities, and areas where the course is considered to contribute (Wenger-Trayner & Wenger-Trayner, 2021).

ACTUAL OR ANTICIPATED OUTCOMES

The data collection for this study is still on-going and is expected to be complete by the end of September 2025. The initial observations from the pre-interviews and the visual mapping process reveal the complexity of the participants' work contexts, which in most cases include numerous connections outside their formal organisations.

The courses are anticipated to enhance both general competences - such as problem-formulation, critical-thinking, system-thinking, problem-solving - and disciplinary competences specific to project management and green transition. They are also expected to drive specific actions and changes within the participants' contexts where these general and/or disciplinary competences will be applied.

The insights will inform the future development of learning design principles for the courses by intentionally enhancing both general and disciplinary competences which can drive specific short-term and long-term actions in the participants' contexts.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

In summary it is still too early to draw any specific conclusion at the current stage, but the data collection is completed and the initial analysis conducted before the conference.

The paper is especially suggested to contribute to the discussion on creative futures, life-long learning and building synergies between academic, industry, public sector and civil society.

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KEYWORDS

Problem-based learning, Professional learning, Capacity Development

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KEYWORDS

Problem-based learning, Professional learning, Capacity Development

Intersectional Barriers to Women's Participation in Mining-Related STEM Professions in South Africa: A Work-in-Progress Analysis of Challenges, Policies, and Pathways to Inclusion

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CONTEXT

The underrepresentation of women in Science, Technology, Engineering, and Mathematics (STEM) fields, particularly in the mining sector, has been a significant issue globally, and South Africa is no exception. Despite various policy interventions and initiatives aimed at improving gender equality in the workforce, women continue to face structural and intersecting barriers in accessing and succeeding in STEM professions. The mining industry, traditionally male-dominated and characterised by gendered workplace cultures, presents additional challenges. South Africa's mining sector remains overwhelmingly male and predominantly white, with women, especially Black women, encountering compounded challenges due to the intersecting factors of race, class, and gender. This study seeks to build upon existing research by examining the specific barriers to entry and advancement that women face in mining-related STEM professions, utilising an intersectional approach to analyse these dynamics in the South African context.

PURPOSE OR GOAL

The primary objective is to examine the structural, cultural, and institutional impediments that hinder women, particularly those from marginalised communities, from entering and advancing in mining-related STEM professions in South Africa. This research seeks to address gaps in the current literature concerning the intersection of gender, race, and class in shaping women's experiences within the mining industry. The study aims to address key research questions: What are the barriers that women encounter in entering and progressing within mining-related STEM fields? How do educational, cultural, and institutional factors contribute to these impediments? The purpose of this research is to provide evidence-based recommendations for overcoming these barriers, with a focus on policy and practice, to promote gender equity within South Africa's mining industry.

APPROACH OR METHODOLOGY/METHODS

This study employs a mixed-methods approach, integrating a survey, semi-structured interviews and/or focus groups, document analysis, and case studies to examine gender inclusion in mining-related STEM professions. The survey will collect quantitative data on workplace experiences, whilst interviews and/or focus groups will provide qualitative insights into barriers faced by women. Document analysis will assess policies and reports, and case studies will identify best practices. Quantitative data will be analysed statistically, while qualitative data will undergo thematic analysis. This comprehensive approach ensures a nuanced understanding of challenges and strategies, informing evidence-based recommendations to enhance gender equity in the sector. I am currently working on my PhD proposal, and I invite guidance and input on this research from academics and industry stakeholders.

ACTUAL OR ANTICIPATED OUTCOMES

The anticipated outcomes of this research encompass a more comprehensive understanding of the intersectional barriers encountered by women in mining-related STEM professions in South Africa. This investigation is expected to elucidate how factors such as race, class, gender, and historical legacies of colonialism and apartheid intersect to influence women's experiences in the mining sector. Furthermore, the research will identify deficiencies in current gender-sensitive policies and highlight efficacious initiatives aimed at promoting gender diversity. The study will provide policy recommendations, including the integration of gender perspectives into STEM curricula, mentorship programmes for women in mining, and the role of technology in fostering inclusive workplaces. Ultimately, the research aims to provide pragmatic solutions for advancing women's participation in mining-related STEM careers.

NEXT STEPS/SUMMARY AND CALL FOR COLLABORATION/INPUT/GUIDANCE

Preliminary analysis/literature review indicates that women's underrepresentation in mining-related STEM professions in South Africa is rooted in intersecting socio-historical, institutional, and cultural barriers. Although policies exist, gaps in implementation and limited attention to intersectional realities hamper progress.

As this research is ongoing, I invite feedback on the mixed-method approach and welcome collaboration and advice for data collection, policy reviews, and the development of targeted mentorship programmes. By partnering with stakeholders across academia, industry, and government, I aim to refine my investigations and co-create strategies for dismantling the deeply rooted inequities in South Africa's mining sector. My ultimate goal is to contribute to broader conversations about inclusive practices, in line with the conference's commitment to community engagement and creative futures.

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KEYWORDS

Women in STEM, Mining sector, Gender inequality, Intersectionality, South Africa, Workplace diversity

Work in Progress: Engineering student perceptions of learning through service (LTS) at Ashesi University, Ghana.

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CONTEXT AND LINK TO OTHER STUDIES.

Learning through Service (LTS), an umbrella term that captures both service-learning (in class) and extracurricular service-based activities, is rapidly growing in popularity in Western engineering programs. Indeed, such offerings can sometimes be a determinant in students' choice of university. Many of them have an international dimension- that is, they train students to identify and work on a problem with a community in a different country, with African countries often featuring in the list. It would be ideal to increase the number of such programs happening on the continent so as to equip students who are more familiar with the context to lead such efforts.

At Ashesi University, a small, private university in Ghana, a number of LTS efforts are underway. The authors have observed that some students gravitate towards these and others lose interest. This study seeks to uncover underlying factors that lead to these differing perceptions.

Multiple studies have been conducted on Learning through Service in the Western world (Folgueiras et al., 2020; Munoz-Medina et al., 2021; Ryan, 2017) and in diverse contexts (Salam et al., 2019), and the benefits gained from this teaching and learning method are noteworthy. This work seeks to elucidate student perceptions of these initiatives and further examine whether the gains made by incorporating LTS in other contexts and continents are being experienced within the African context. Understanding the African student perceptions, interests, and motivators can enable African institutions to better design such programs to effectively equip students, steer them onto such pathways, and also add to the data on the growing discourse of promoting other teaching and learning methods on the African continent.

PURPOSE OR GOAL.

Learning through Service pedagogies are built on a rich body of theories. Those developed by Kolb, Dewey, Piaget, Vygotsky, and Kohlberg can all be said to inform the approach of engaging students experientially with a problem, through which they make meaning and produce tangible artefacts.

Several studies show the value of LTS in terms of knowledge and skills development and promotion of prosocial behavior (Bielefeldt et al, 2010; Salam et al., 2019; Lin and Shek, 2021; McDougle and Li, 2023). It is also likely helpful for increasing participation of women (Matusovich et al, 2013; Manoosingh, 2015) and improving diversity and retention efforts generally (Oakes et al, 2018). (Bengic-Colak et al, 2023) shows that partaking in a long-standing LTS program is valuable in increasing their personal and social contributions. Although it is stated that LTS also has the advantage of being able to develop student identity and attitudes through such programs (Bengic-Colak et al., 2023), less effort has been made in studying this directly. If such offerings are to grow in the African context, it will be helpful to understand student perceptions of these options and how their identity and attitudes may change through their engagement with them.

The research questions are 1) What are Ashesi engineering students' perceptions of LTS offerings? 2) What contextual factors contribute to those perceptions?

APPROACH OR METHODOLOGY/METHODS.

A narrative inquiry approach will be used to elucidate these perceptions. Approximately ten students and alumni of Ashesi University's engineering program will be engaged. Similar to the approach used by (Jones et al, 2008; Bengic-Colak et al., 2023), they will be asked to talk about their experience and share a story related to their SL experience that they still think about. A cross-section of the target population will be engaged – both those who have actively participated in service- learning projects beyond what was required in the curriculum and those who haven't. Interviewees will also include some Ashesi students/alumni who have interacted with counterparts in the US, such as through study abroad semesters, presenting at conferences, and pursuing graduate studies, to elicit their view on the difference between perspectives developed by Ashesi students and those in the US.

ACTUAL OR ANTICIPATED OUTCOMES

Preliminary observations, drawn from informal conversations held between the first author and her former students, suggest a few themes that may emerge from the analysis. Factors that may be overlooked in other contexts emerge. For example, paying their own transport fare to travel to a remote community to carry out their project can be a demotivator. Some students feel that pursuing impact is something they can do after they've built a financial foundation for themselves and developed their professional network.

The element of intrigue for what one has yet to experience may be at play for both African and American students. Students coming to Ashesi tend to be highly successful academically and therefore driven to pursue the highest levels of opportunities available to them, which may appear to be pursuing studies/job opportunities in a more "developed" context. Western students, on the other hand, may be intrigued by the novel experience of visiting a rural community in another country and are therefore motivated to pursue that opportunity.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

It is expected that this work in progress will reveal some preliminary findings and lay out a path for next steps in elucidating student perceptions around this pedagogical approach. Findings may be specific to the unique context of the authors' institution, but nonetheless can help begin to paint a picture of some dynamics present in the African context, which can guide the improved design of such programs for the continent.

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KEYWORDS

Service-learning, perceptions, Ghana

Enhancing the 21st-century learning skills through problem-and project-based hybrid learning: A perspective from Gulu University, Northern Uganda

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KEYWORDS
21st century learning skills, project-oriented learning, hybrid problem-based learning

CONTEXT

Globalisation and advancement in information and communication technology have significantly changed the 21st-century work environment. The work environment experienced dramatic shifts in technology, knowledge systems, human mobility, and production systems (van der Laan et al., 2023). Consequently, the occupation-specific skills are no longer sufficient for graduates to meet the needs of labour markets (Suarta et al., 2017). Employers' surveys show that success requires more than just knowledge and skills in a specific discipline, highlighting the need for broader competencies across all fields and education levels (Suarta et al., 2017; Wolff and Booth, 2017). For students and workers to cope with the new, changed requirements of the contemporary job environment, they need to acquire additional skills and attributes, commonly called 21st-century learning or employability skills, including information and communication skills; thinking and problem-solving skills, as well as interpersonal and self-directional skills. However, the traditional university teaching and learning methods cannot effectively deliver these skills, as most current university graduates lack many 21st-century learning skills (Lavi et al., 2021; Popović, 2014). Multiple studies also indicate that employers find today's graduates unprepared for the evolving workplace (Wolff and Booth, 2017).

In an attempt to contribute towards overcoming this learning challenge, a problem-and project-based hybrid learning (PPHL) method was piloted in Gulu University. PPHL is a unique and innovative learning method that transcends traditional problem-based learning (PBL). It integrates design thinking and the traditional teacher-centred

learning into the student-centred PBL to form a hybrid learning method employing information and communication technology in both online and face-to-face lectures. Being a new teaching and learning method, its effectiveness is less understood and documented. This paper analyses how the problem-and project-based method contributes towards overcoming the contemporary learning challenges. `

PURPOSE OR GOAL

The study aims to assess the effectiveness of the problem-and project-based hybrid learning in enhancing 21st-century learning skills. Specifically, the study seeks to answer the following questions:

I. How does PPHL enhance the 21st-century learning skills?
II. When is PPHL effective in enhancing 21st-century learning skills?

This study has three major contributions: Firstly, it provides the basis for upscaling the problem-and project-based hybrid learning method. Secondly, it highlights areas of improvement in the implementation of the problem-and project-based hybrid learning. Thirdly, it broadens the understanding of alternative teaching and learning methods.

THEORETICAL FRAMEWORK AND METHODOLOGY

A constructivist theory guided this study. The theory posits that learning is active rather than passive, and it is built from experiences (Bada and Olusegun, 2015). In constructivist learning, teachers and students share knowledge and authority (Tam, 2000). Learning activities encourage student-centered learning, collaboration, reflection, metacognition, the use of multiple modes of representation (video, audio, and texts); enable students to determine how they will learn; provide experience in and appreciation for multiple perspectives (evaluation of alternative solutions); and embed learning in realistic contexts (Honebein, 1996). Students in constructivist learning are more knowledgeable, creative, and innovative with better critical, analytical, communication, and collaborative skills (Bada and Olusegun, 2015).

In terms of methodology, the study adopted a correlational design and a quantitative method. Using a structured questionnaire, we collected primary data from 45 postgraduate students who participated in course units facilitated through the problem-and project-based methods. Data was collected on elements of problem-and project-

based hybrid learning and 21st-century learning skills, notably: the use of design thinking and hybrid course delivery and assessment modes, participation in group discussion and fieldwork activities, critical thinking skills, creativity and innovation, collaboration, communication, digital skills, growth mindset, and learning how to learn. Measurements of 21st-century skills followed from previous studies. Relationships between problem-and project-based hybrid learning and 21st-century skills were assessed using STATA, which generated descriptive and inferential statistics.

ACTUAL OR ANTICIPATED OUTCOMES

Although responses regarding the impact of problem- and project-based hybrid learning (PPHL) on other 21st-century skills were inconclusive, the evidence concerning its relationship with critical thinking, creativity, and innovation was definitive. There was substantial disagreement over whether participation in group discussions, fieldwork, hybrid courses, and hybrid assessment methods contributed to the development of critical thinking skills. Notably, male and married students showed more disagreement than female and single students regarding the positive effects of PPHL on critical thinking. Conversely, engagement in fieldwork was significantly linked to the development of creativity and innovative skills.

More students developed creativity and innovation skills than critical thinking skills, likely due to the differing timeframes needed for their acquisition. This finding aligns with Baker et al. (2001), Halpern (1998), and Lai (2011). Baker et al. suggest that teaching aimed at fostering thinking skills requires a longer period and is more challenging compared to promoting creativity and innovation. Halpern and Rai consider improvements in critical thinking as gradual and incremental. The stronger disagreement among male and married students regarding the positive influence of problem- and project-based hybrid learning on critical thinking may be attributed to their higher enrollment rates.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

This study indicates that problem- and project-based hybrid learning did not significantly enhance critical thinking skills but did promote improvements in creativity and innovation. However, the results regarding its impact on other 21st-century skills remain inconclusive. The observed positive effect on creativity and innovation aligns

with constructivist theory. Although the study offers some insights into how this learning approach affects 21st-century skills, its findings are limited due to a small sample size.

These findings have important implications for curriculum design, education policy, and future research. Firstly, curricula and policies should incorporate ongoing critical learning activities across various educational levels. Secondly, practical activities such as fieldwork should be integrated into teaching and learning processes. Lastly, given the limited sample size of this study, more extensive and comprehensive research is necessary to better understand the effects of problem- and project-based hybrid learning on 21st-century skills.

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Creating context-specific problem-based learning materials for Engineering Education in South Africa: reflections on challenges and outcomes of the BambaSonke Design

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CONTEXT

Engineering education in South Africa has experienced a strong call for decolonizing curricula, requiring learning about and designing for local challenges rather than imported case studies. This decolonization process demands educational materials that reflect local realities and knowledge systems. Problem-Based Learning (PBL) offers valuable opportunities for developing professional skills, but resource constraints in South African universities often hinder the development of contextually relevant materials. The first iteration of the Bambasonke Design Challenge, meaning "take hold together" in isiZulu, represents a response to this need by focusing an engineering design challenge on an informal settlement called Dunoon, a township in Cape Town, which faces significant challenges in water access, sanitation, energy reliability, and waste management. The Engineering for People Design Challenge, run in collaboration with EWB-SA and EWB-UK, demonstrated the value of design challenges in engineering education (Engineers Without Borders UK, 2024). However, South Africa's unique socio-economic landscape necessitated the development of a locally-conceived and contextually rich design challenge toolkit, for both engineering education students and academics, which specifically addresses South African contextual challenges, and specifically in the context of an informal settlement.

PURPOSE

This proposal aims to document and analyse the development and implementation of the BambaSonke Design Challenge, created through collaboration between the Innovative Engineering Curriculum (IEC) initiative and Engineers Without Borders South Africa (EWBSA) during 2024. We investigate how context-specific problem-based learning materials addressing real South African challenges can be effectively developed. Our study examines the pilot implementation across two institutions with different teaching objectives: In 2024, an introductory civil engineering course at UCT structured around urban metabolism and technical design, and a communications course at CPUT focused on interpersonal skills. The research captured lessons from these initial pilots and informed the expansion in 2025 to the University of Pretoria and CPUT 4th year students, representing a strategic scaling of the initiative across different institutional contexts and academic levels. This research aims to provide a foundation for launching the BambaSonke Design Challenge to other South African universities in 2026 and beyond by documenting initial challenges, successes, and refinement opportunities. By exploring the development and implementation process, we seek to create a sustainable model that enables engineering educators across South Africa to incorporate authentic local challenges into their curricula, thereby advancing the decolonization of engineering education.

APPROACH

We employed Gibbs' (1988) reflective cycle as our methodological framework to systematically examine our experiences developing and implementing the BambaSonke Design Challenge toolkit. This six-stage cycle – description, feelings, evaluation, analysis, conclusion, and action plan – provided a structured approach to analysing both the development process and educational outcomes. The design challenge was piloted at UCT and CPUT during the second half of 2024, and at UCT, CPUT and UP in 2025 with projects rolled out in parallel along with resource development. Data collection included detailed educator reflective journals documenting the development process and challenges, structured interviews with educators and tutors, structured classroom observations, student feedback surveys following completion of the challenge, and qualitative analysis of student assignments addressing specific challenge areas in Dunoon township (including water, sanitation, energy, waste, transport, and food security). This multi-faceted approach allowed us to capture the complexity of developing and implementing locally relevant design challenges while simultaneously planning for wider dissemination to other South African universities, including the University of Pretoria and advanced undergraduate courses at CPUT in 2025.

OUTCOMES

The pilot implementation revealed both challenges and significant positive outcomes. Developing the extensive contextual content about Dunoon township, including geographical, cultural, and infrastructure details, required substantial effort by the EWB team but ultimately facilitated an immersive learning experience. Creating an engaging learning experience using this content by partner academics was equally challenging and exhilarating. Students demonstrated high engagement levels when addressing authentic local challenges, with classroom observations revealing energetic discussions as they grappled with complex socio-technical problems. Student submissions showed improved understanding of the relationships between social and technical systems in informal settlement contexts. However, the parallel implementation across different institutions highlighted the need for clearer task instructions and more explicit assessment rubrics to guide students effectively. Despite these implementation challenges, qualitative evidence suggested students gained substantial learning beyond quantifiable measures, developing professional skills in contextually relevant scenarios. The pilot phase in 2024 provided valuable insights for refining the toolkit before the 2025 expansion to the University of Pretoria and CPUT 4th year students, particularly regarding the structure of supporting materials and assessment frameworks appropriate for various institutional contexts and student experience levels.

CONCLUSIONS

The BambaSonke Design Challenge represents a significant contribution to decolonizing engineering education in South Africa by providing locally relevant, context-specific learning materials addressing authentic challenges in informal settlements. It also provides an effective educational model that prepares future engineers to work respectfully and effectively in complex social environments while delivering tangible benefits to partnering communities. Our reflective analysis demonstrates that despite initial resource constraints and implementation challenges, context-specific PBL materials yield valuable educational outcomes that connect technical knowledge with social understanding. Based on the pilot implementation in 2024, we refined our content, web accessibility and supporting materials before expanding to the University of Pretoria and CPUT 4th year students in 2025. The parallel implementation across different courses and institutions confirmed the toolkit's adaptability to various educational

objectives and student levels. As we prepare to launch the BambaSonke Design Challenge more broadly, this pilot phase has established a foundation for a sustainable, collaborative approach to engineering education that centres South African contexts and challenges. This work contributes not only practical insights for educators but also a model for creating educational materials that prepare future engineers to address South Africa's unique challenges through socially and technically appropriate solutions. As such, participation in the BambaSonke Design Challenge is now available to universities in South Africa upon request.

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KEYWORDS

Problem-based learning, BambaSonke Design Challenge, engineering education, curriculum decolonization, informal settlements

Teaching care as part of engineering ethics

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CONTEXT

"Your practice is your ethics!" is the challenge issued by Schmidt in relation to the teaching of engineering ethics (Schmidt 2014, 1008) and draws attention to the way in which what we do is intimately related to who we are and our choices and decision-making. Trevelyan argues that social interactions lie at the core of engineering practice (Trevelyan, 2010) and, in this context, care is positioned as a distinguishing characteristic of engineering practice that integrates knowledge, identity and action in a manner closely tied up with developing competence. Care ethics was seen to emerge out of a feminist concern to profile care as a distinct way of being in the world (Tronto, 1993) that has subtly challenged the technology-focused and efficiency-based foundations of engineering (Nair and Bulleit, 2020; Riley 2008). Tronto's work gives structure to what a care ethic involves in her identification of four different aspects of care: *caring about*, *taking care*, *giving care* and *receiving care* (Tronto, 1993), with the later addition of *caring with* (Tronto, 2013).

As such, in this research, teaching care is positioned as an essential and valuable part of the engineering curriculum that needs to be profiled explicitly in teaching, in learning outcomes and in assessment.

Stepping into the re-design and assessment of a course in Social Infrastructure provided the opportunity to examine existing and new curriculum choices in terms of a framing of care that recognised social relationship as integral to both infrastructure and curriculum choices. The Social Infrastructure course is an optional 20 credit course offered for up to 100 students from across the range of engineering programmes within the Engineering and Built Environment Faculty at the University of Cape Town. From the outset, it was evident that learning outcomes needed to be conceptualised to include the experiential and affective, thus inviting the possibility of course design aimed to embody relationality and care.

PURPOSE OR GOAL

This study sets out to examine how the different elements of care identified in Tronto's framework can be incorporated in a range of curriculum initiatives within an existing course. It sets out to examine how the theory and practice of an "ethics of care" can be integrated into the planning, structure and implementation of a cross disciplinary course so as to model care as an integral part of engineering. As such, Tronto's five elements of care are presented and examined to provide a flexible and unifying structure for curriculum innovation and practice.

METHODOLOGY

This research draws on Tronto's ethics of care as a multi-faceted lens to critically examine curriculum innovations within an existing course offering. The different elements of the Social

Infrastructure course were analysed in terms of how they exemplified Tronto's five elements of care and in terms of Schmidt's three forms of knowing: "to know"; "to do" (or "to create") and the practical wisdom exercised as *judgment* (Schmidt, 2014) that shifts learning beyond head knowledge to incorporate the exercising of judgment that leads to action.

ANTICIPATED OUTCOMES

Reflecting on, consolidating and profiling the different elements of knowing in terms of Tronto's five elements of care included the following:

- *Caring about* – The challenges of decision-making and feedback tested staff, tutor and course participants attentiveness to one another and to community partners needs. There was evidence of empathy in action and stepping up to anticipate and resolve challenges. This extended into the assessment of the course.
- *Caring for* – Recognising and articulating the scale of responsibility in relation to the different stakeholders required courage and tenacity. This was demonstrated and achieved in collaboration rather than being an individual expert's sole responsibility.
- *Care-giving* – Distinguishing between taking responsibility and providing care drew attention to the myriad of small decisions and the range of skills required to ensure competence of care-giving. By positioning participation in the course as a journey, this allowed the different role players to experience practical instances of care-giving.
- *Care receiving* – Because a large element of the course design involves interacting with stakeholders and community partners, explicitly building in responsiveness to the exercise and experience of care was a valuable exercise that solidified the co-production elements of the course.
- *Caring with* – Solidarity was established through co-production with teammates and community partners, where the formulation of worthwhile and achievable goals in conjunction with explicit values to generate commitment and innovation in the face of practical and environmental challenges.

Consequently, the results of the research demonstrated the intentional way in which care can be threaded through the elements of course design, implementation and assessment.

CONCLUSIONS

A focus on Tronto's five elements of care supports an integrated approach to course design that combines planning, implementation and assessment in a way that is relational, responsive and reciprocal. The explicit and scaffolded focus on care within engineering education supports an enhanced conception of engineering competence that intentionally integrates theory, identity and action in a way that builds purpose into the engineering programme.

This recognises that engineers are increasingly called to justify the impact of their designs and systems on people, communities and the environment and that care ethics provides a vocabulary to do so. As such, care is recognised as a distinct, alternative vocabulary and approach to the efficiency ethos that has long been the culture of engineering.

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KEYWORDS

Engineering ethics, ethics of care, curriculum design.

Emotion and engineering identity in small group learning – piloting a computational model approach

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Abstract

Engineering students are increasingly expected to tackle ill-structured, wicked problems, but doing so can be emotionally challenging for students unaccustomed to uncertainty, ambiguity, and conflicting worldviews. Emotional support is crucial, but there is no consensus on what it can consists of and how educators can provide it. In this contribution, we focus on how engineering students deal with negative emotions when they are asked to engage in learning activities that they consider to be outside of the scope of engineering education, that is, they experience identity tensions. The aim is to develop a better understanding of the emotional dynamics of small group learning and lay the foundation for developing adequate emotional support for engineering students learning to deal with wicked problems. To do so, we pilot an innovative approach that combines affect control theory (ACT) with agent-based modelling (ABM). We will use empirical data from video-recorded group work to test and calibrate the model. During the conference, we illustrate and discuss the model's affordances for engineering education research. We hope that the model can provide a first step towards better understanding the emotional dynamics of small group learning and identity development in engineering education, and a practical tool for designing emotionally supportive learning environments that help students embrace uncertainty and ambiguity as part of becoming better engineers.

CONTEXT

Engineering students are increasingly expected to learn how to deal with ill-structured, wicked problems, in contexts such as sustainability education (Lönngren, 2017), ethical decision making (Corple et al., 2020), design projects (Ge & Leifer, 2020), or interdisciplinary problem-based learning (Feng et al., 2024). A growing body of research is showing that learning in these contexts can be emotionally challenging for engineering students who are not used to working with uncertainty, ambiguity and conflicting worldviews, and that students may need emotional support to be able to productively engage in ill-structured problem solving (Holmén & Lönngren, accepted; Swenson et al., 2024). There is, however, no consensus yet on how educators could provide emotional support. Some suggest that students need individualized support (Feng et al., 2024), others have questioned the feasibility of such an approach, arguing that emotions and emotional support should be viewed as a distributed system (Holmén & Lönngren, accepted; Leach & Bou Zeineddine, 2021).

PURPOSE OR GOAL

The purpose of this contribution is to pilot an innovative approach for studying emotions in small group learning in engineering education. We combine affect control theory (ACT) with agent-based modelling (ABM; Rogers et al., 2014; Zöller et al., 2021) to be able to model

emotions in small group learning as a distributed, dynamically evolving system. More specifically, we are interested in the ways in which engineering students individually and collectively deal with negative emotions when they encounter identity tensions (Yang et al., 2022), for example when they are frustrated because they feel that dealing with wicked problems does not fit their conception of what it means to be an engineer. Ultimately, we hope to be able to identify elements of small group learning environments that could be changed to facilitate more productive emotional engagement with wicked problems (Holmén & Lönngren, accepted).

APPROACH OR METHODOLOGY/METHODS

Studying emotions as a distributed system is easier said than done, which is why we need to develop a new approach. ACT provides a mathematical tool for studying emotions in social interaction, through the lens of social identity (Rogers et al., 2014). In this contribution, we present an ACT-based ABM that can be used to simulate how engineering students conceptualize and negotiate engineering (student) identities and how students' social identities can shape (and be shaped by) their emotional experiences and expressions during small group learning. We then use empirical data from video-recorded group work on wicked problems to iteratively test and calibrate the model.

ACTUAL OR ANTICIPATED OUTCOMES

We anticipate presenting a pilot version of an ACT-based ABM for studying emotions – and their relations to students' social identities as engineering students and/or future engineers – in small group learning environments. We will illustrate the model and its affordances for engineering education research with data from video-recorded group work on wicked sustainability problems.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

Educating engineering students for an ever more complex and uncertain future requires a nuanced and systemic understanding of the emotional processes involved when students learn to address wicked and ill-structured problems. Our pilot model provides a first step towards developing such an understanding. In the future, we hope to use the model to design emotionally supportive learning environments that allow engineering students to develop engineering (student) identities that embrace uncertainty, ambiguity, and value conflicts as a natural part of becoming a (better) engineer.

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KEYWORDS

Wicked problems, emotions, engineering identity, agent-based-modelling

Staff reflections on the interdisciplinary project at the Wits School of Arts: Enabling Caring Pedagogies and Sustainable Education

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Abstract:

Education stands at the intersection of social and ethical responsibilities, demanding pedagogical approaches that foster sustainable and transformative learning experiences. Caring pedagogies, rooted in feminist ethics of care (Gilligan, 1982; Noddings, 2013), emphasize relationality, empathy, and attentiveness to the needs of students as a foundation for inclusive and sustainable education.

This project explores how staff at the Wits School of Arts (WsoA) conceive of and deploy multi-, inter- and transdisciplinarity in their Teaching and Learning practice and research, both in the history of the school and in our current context. Interdisciplinarity is conceived of in the staff body as a nebulous, indeterminate, 'in-between' conception of knowledge making that requires diverse pedagogic approaches. This capacious conception is positioned as central to caring pedagogies in our diverse context. This project attempts to trace the "patterns of consensus and fault lines of debate" (Klein 2017, p.21) between WsoA staff, highlighting the shared interest in interdisciplinarity as a vehicle for fostering responsive, caring and ethical relationships between students and educators. By drawing from interdisciplinary perspectives, including critical pedagogy (Freire, 1970) and decolonial thought (Mignolo, 2011), we argue that caring pedagogies are intertwined with interdisciplinarity, as it provides an essential framework for addressing the epistemological and social crises embedded in contemporary education systems. Drawing on the discussions of our research group, centered around the "Typologies of Interdisciplinarity" outlined by Julie Klein (2017), we emphasize a conception of interdisciplinarity as "critical" rather than "instrumental" (ibid. p.28), arguing that interdisciplinarity can be a means of opening up knowledge practice, exposing tensions between knowledge practices, and dehierachising knowledge systems. In this conception, interdisciplinary approaches and knowledge are conceived of as working towards "transdisciplinarity", transgressing false hierarchies and taxonomies (ibid. pp. 29-30). We see this as central to caring pedagogies designed to cater to diverse students in a context of diverse knowledge practices and central to advancing epistemic justice. We argue that this work is crucial to creating African universities that meaningfully serve our diverse population and is essential to creating socially sustainable education systems for our students.

Caring pedagogies emphasize the affective and ethical dimensions of education, shifting the focus from rigid curricular structures toward a more holistic, student-centered approach. Noddings (2013) posits that care ethics in education requires responsiveness, responsibility, and reciprocity—values that resonate with the principles of sustainable education. In this regard, sustainable education extends beyond environmental awareness to encompass social justice, community engagement, and ethical responsibility (Sterling, 2001). Incorporating caring pedagogies into sustainable education also challenges dominant paradigms of knowledge production that often prioritize efficiency, competition, and individualism over collaboration and well-being. Drawing on bell hooks' (1994) notion of engaged pedagogy, this project examines how interdisciplinary, participatory and dialogical learning processes enhance students' capacity to engage with complex social issues. This is associated with the argument that sustainable education must integrate diverse epistemologies, recognizing indigenous and non-Western knowledge systems as vital to fostering care-based approaches to learning (Escobar, 2018; Andreotti, 2015).

This project further explores the intersection of emotional engagement and critical pedagogy in sustainable education. Research suggests that affective dimensions of learning—such as empathy, compassion, and interconnectedness—play a crucial role in fostering long-term commitments to sustainability (Boler, 1999; Kimmerer, 2013). While we acknowledge the importance of the climate crisis in our current context, the focus of this project is on social sustainability. By incorporating experiential learning, storytelling, and relational approaches to teaching, educators can bridge the gap between abstract sustainability concepts and lived experiences, making learning more meaningful and impactful.

Through discussion of a range of examples from the school including historical curriculum documents, current degree configurations, and reflections on personal teaching experiences and research foci, the staff of WSoA attempt to outline some of the alignments, points of tension, and divergences in how they conceive of interdisciplinarity - in both underpinning and facilitating caring pedagogies. We argue that interdisciplinary conceptions and approaches to Teaching and Learning support an ethic of care and sustainable practice. We contend that a shared, holistic understanding of the interdisciplinary project in the school cultivates collective responsibility and social consciousness in staff and students and prepares students to navigate and transform their social realities.

The staff in this project aim to outline our shared and divergent understandings of multi-, inter- and trans-disciplinarity in the context of Teaching and Learning in the arts. To facilitate this process, representatives from our team will participate in a 'fishbowl' format, presenting their reflections in a roundtable discussion in an inner circle. This will then be opened to the outer floor of observers, in hopes that areas of shared understanding are 'thickened', and new contradictions and flights of thought begin to emerge.

In conclusion, caring pedagogies offer a transformative lens for reimagining education as an ethical and relational practice. By integrating care ethics, decolonial approaches, and critical pedagogy, educators can create learning environments that foster sustainable thinking and action. This project seeks to map and clarify the existing conceptions and practices in the WsoA staff body, calling for a paradigm shift in education—one that embraces care not as a peripheral value, but as a fundamental principle for cultivating sustainable futures in an epistemologically diverse context.

Keywords: Caring Pedagogies, Sustainable Education, Critical Pedagogy, Interdisciplinarity, Ethic of Care

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Transforming Learning Environment Towards PBL-Hybrid: A Case of Student-Centered eLearning Implementation Methodology in Gulu University

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CONTEXT

Traditional pedagogies emphasise instructor-led delivery in structured face-to-face settings which often limit inquiry, collaboration and self-regulated learning (Baran, 2013). In contrast, Problem-based learning promotes the *process* of student-centred inquiry into real-world problems and stimulates reflection and collaborative meaning-making (Kolmos & De Graaff, 2015). Project-based Learning however, adds focus on hands-on tasks resulting in *tangible outputs.* Thus, its integration with Problem-based learning combines analytical depth and practical tasks (Kolmos & De Graaff, 2015). These pedagogical methods can be delivered through hybrid learning which blends online and face-to-face delivery modes and enables engagement across digital, physical and social spaces (Eyal & Gil, 2022).

Despite these possibilities, contradictions between passive teaching and active learning, mismatches between pedagogy and technology and limited teacher training remain unresolved in resource constrained universities. While previous studies explored problem- and project-based learning (PBL) and hybrid learning, structured methodologies for supporting systematic shift from traditional to PBL-Hybrid learning remain underexplored. This study addresses both gaps in knowledge and practice.

PURPOSE OR GOAL

To explore: (i) how Gulu university employed student-centered eLearning implementation methodology (SCeLIM) in its *PBL-Hybrid Learning Beyond COVID-19 Project* to redesign some master of arts courses and transform learning environment and, (ii) how the SCeLIM supported the transition. We ask: (i) How were PBL-Hybrid learning activities sequenced? and (ii) How did SCeLIM shape transformation of learning environment? Thus, contributing to the understanding of a structured methodology for ICT integration and pedagogical change and offering practical guidance for universities moving from teacher-centered to student-centered approaches.

APPROACH OR METHODOLOGY/METHODS

A holistic single-case study, guided by a social constructivist's paradigm, was used to explore SCeLIM's role in *PBL-Hybrid Learning beyond Covid-19 Project*. The researchers adopted a reflexive stance as participant-observers. Six purposively selected teachers and 139 students participated in the study. Field notes and focus group discussions transcripts were collected over three semesters and analysed using *process tracing* and reflexive thematic analysis. Process tracing was used to map activity sequencing (RQ1), while reflexive thematic analysis was used to understand the transformation of the learning environment (RQ2). Ethical clearance was obtained from Gulu University Research ethics committee.

ACTUAL OR ANTICIPATED OUTCOMES

Activity workflows (RQ1): Between May 2023 and October 2024, three implementation pilots involved team alignment, teacher training, course redesign, student orientation, stakeholder engagement, problem resolution and many others. Pilot 1 established a shared vision, introduced design thinking with PBL-hybrid concepts, identified pedagogical and digital gaps and guided ICT use (Moodle, WhatsApp, Google Suite etc.). Pilot 2 launched new courses, improved Moodle and built teacher competences through mentoring and thematic meetings. Pilot 3 emphasised iterative improvement, additional training, balancing student autonomy with teacher guidance and aligning ICT tools with learning outcomes and local contexts.

Transformation of learning environment (RQ2): Before the project, teaching was mainly lecture-based with limited attention to design thinking or conscious ICT integration. Through SCeLIM, courses were redesigned to consciously integrate design thinking, ICTs as mediating artefacts, problem-solving and other 21st century skills. Iterative activities strengthened teachers' knowledge and reflective practice.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

The SCeLIM provides a structured but flexible and context-sensitive pathway for implementing PBL-Hybrid learning in resource-limited universities. Evidence indicates that contradictions between passive teaching and active learning, mismatch between pedagogy and technology and limited teacher training can be addressed through conscious ICT integration, collaboration, mentoring and support structures. The methodology progressively enhanced teacher competence, course quality and student engagement. These findings confirm earlier studies by Geisinger (2016), Willingham (2010) and Eyal & Gil (2022) highlighting potentials of PBL and hybrid learning and extends them by demonstrating a structured implementation methodology. Thus, SCeLIM offers practical evidence for resource-limited universities facing slow adoption. Future research should examine causal mechanisms. Policymakers should prioritise teacher development and ICT capacity.

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KEYWORDS

Problem-Based Learning, Project-Based Learning, Hybrid Learning, Learning environment

Leveraging Undergraduate Research for Emerging Academic Staff Development: A Mentorship Pipeline in Engineering Education

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CONTEXT AND BACKGROUND

In recent years, there has been an increasing drive in South African universities to prioritise research and publication, particularly at research-intensive universities. This is coupled with a drive to build capacity among the new generation of academics, representing post-Apartheid diversity, transformation and inclusivity. The country is currently characterized by its young academic cohort (Rapanyane, 2021), who experience particular challenges, not only imposter syndrome (Chakraverty, 2021), but also how to effectively balance teaching, research and community engagement (Badat, 2004). While supporting these academics, particularly in institutions that value high publication outputs, requires different strategies such as mentorship and communities of practice (Baiduc et al., 2016), a golden opportunity is the 'grow your own timber' (Sehoole & Ojo, 2015) approach to develop new PG cohorts through supporting final year UGs. Although UG mentorship by more experienced academics is time-consuming (Linn et al., 2015), this is an ideal space for new academics.

We, as new generation engineering academics at a research-intensive university, are tasked with undergraduate teaching and learning, and supervision of honour's level research projects. During the engagements with students, we recognised the potential in students to conduct undergraduate research (UGR) based on their honour's projects. Moreover, we recognise how early introduction to research (UGR) may create a pipeline for postgraduate research (PGR), thereby increasing our graduate retention. Additionally, it is noted that other faculties, like medicine, integrate their UGR into their curriculum and encourage students to present their work at conferences. This allows for the collaboration of industry partners and projects, and may lead to international collaboration with more seasoned academics.

PURPOSE OR GOAL

This paper presents an undergraduate research initiative that targets final-year engineering (honours) student projects as conference papers.

The initiative, as outlined in Figure 1, implements a structured research capacity-building process workshop (Matus et al., 2018) through a series of semi-formal workshops. These workshops provide mentorship to students in key aspects of academic writing and dissemination, including abstract development, manuscript preparation, peer review, and the presentation of scientific findings. Furthermore, the initiative fosters collaboration across multiple levels, engaging academic staff, master's students, and international exchange students. Additionally, it offers participants the opportunity to gain firsthand experience in academic research by presenting their work at a scholarly conference.

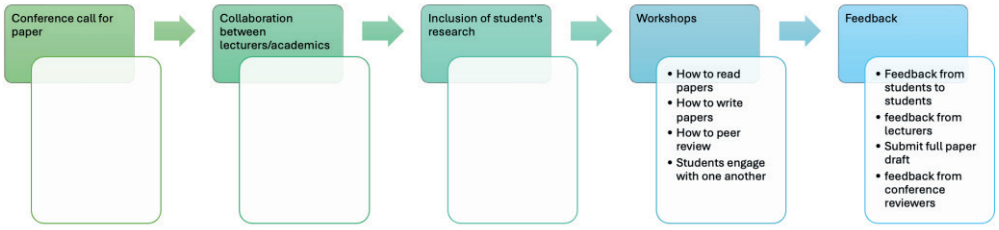

Figure 1: Process flow for group conference development

APPROACH OR METHODOLOGY/METHODS

This initiative follows a two-phase, community of practice (COP) approach that brings together academic staff, postgraduate students, and undergraduates to form an inclusive research community. By minimizing barriers between these groups, it fosters multi-level collaboration and support. Our approach involved submitting seven papers to a locally hosted international conference (CLF2025), all subjected to a double-blind review; six were accepted, and one was rejected, corresponding to lower participation in the research capacity-building sessions. Phase 1 (detailed in this work-in-progress) uses Participatory Narrative Inquiry (PNI) conducted after papers were accepted but before the conference presentations, while Phase 2, informed by Lewis et al., will employ focus groups following the conference. Figure 2 showcases the undergraduate research framework, whilst highlighting the vertical and horizontal engagement that occurs across the various departments for each of the papers submitted.

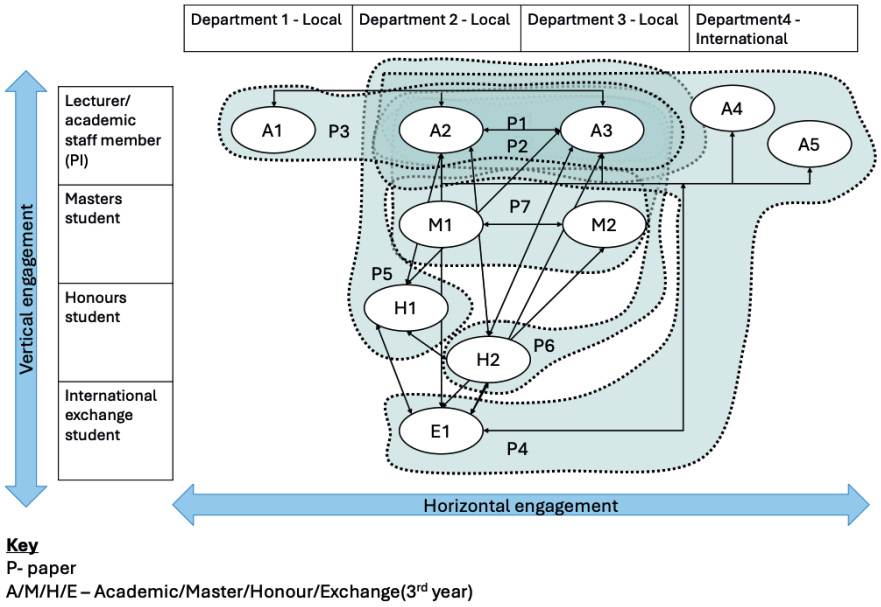

Figure 2: Undergraduate research framework - Vertical and horizontal engagement across various departments (Authors' own work - Work in progress)

Future research plans to test and expand on this framework with different cohorts of students, over various year and at different conferences. Essentially, aiming to design a holistic framework to guide future new generation young academics in harnessing undergraduate research for future projects.

ACTUAL OR ANTICIPATED OUTCOMES

A Positive Negative Interesting (PNI) survey was conducted using this cohort of students. The results of the PNI are summarized as follows:

Positives: The PNI workshop offered valuable early exposure to scientific writing, with participants gaining practical experience, supportive guidance, and close collaboration in a low-pressure setting. Students appreciated the challenge and learned crucial skills for future research, such as a Bachelor's thesis.

Negatives: Scheduling proved tight, particularly for late starters, and time constraints sometimes strained the process. Feedback arrived during breaks, requiring quick revisions. Some suggested more workshops or in-person peer review to improve timing and communication.

Interesting: Refining large research into concise manuscripts sharpened analytical thinking. Varying writing styles enriched learning, while conference presentation heightened motivation and provided visibility.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

This venture highlights the potential for engineering UGR to be presented as conference papers. It emphasises the value in research mentorship to undergraduates and the value of creating a research community of practice for students and academic staff. Furthermore, this creates a platform for the cross-collaboration within the faculty, industry partners, industry projects and international collaboration with more seasoned academics.

While this study made use of a small cohort of students to trail this approach, it is recommended that future studies explore the implications of this approach with larger groups of students. Future research should follow up with participants in qualitative interviews to understand and unpack their experiences around UGR. Moreover, it is suggested that an analysis of cognitive impact of the study as per Lewis et al (2025) be conducted.

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KEYWORDS

Undergraduate research, next-generation academics, community of practice

Awareness of Universal Design for Learning Among Health Science Profession Educators at University of The Free State

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CONTEXT

Health science disciplines have unique pedagogical requirements and specialised content, which serve as a critical area to explore the integration of Universal design for learning (UDL) principles(Kennedy et al., 2018). Universal Design for Learning (UDL) is a framework designed to address the diverse learning needs of all students and it involves proactively applying instructional design concepts, pedagogical knowledge, and instructional technology to create accessible instruction that engages learners across a broad spectrum of abilities (CAST, 2018).Studies document that teachers play a central role to the successful implementation of UDL in higher education institutions(Craig et al., 2022). However, Literature evidence reveal that many teachers lack awareness of the UDL framework and currently there are no studies have explored the awareness of UDL among health science professional educators in South Africa. Therefore, this study aims to evaluate the awareness among health science professional educators at university of the free state regarding the UDL framework

PURPOSE OR GOAL

The motivation behind this study is to assess the level of awareness and understanding of Universal Design for Learning (UDL) among health science professional educators at the University of the Free State (UFS). Studies indicate that teachers play a pivotal role in successfully implementing UDL in educational settings; however, there is a lack of research examining the awareness and application of UDL among health science educators, particularly in South Africa. This this study seeks to fill this gap by evaluating the awareness health science professional educators at UFS regarding UDL principles and whether they incorporate them into their teaching practices.

APPROACH OR METHODOLOGY/METHODS

To assess UDL awareness among health science educators, an anonymous online questionnaire will be developed and distributed to academic staff at the University of the Free State. The questionnaire will consist of two sections: one focusing on demographic information and teaching practices, and the other exploring participants' knowledge, experience, and opinions regarding UDL. Data will be collected through both closed and open-ended questions to gain insights into educators' familiarity with UDL principles and their integration into teaching. The findings will guide recommendations for enhancing UDL adoption in health science education.

ACTUAL OR ANTICIPATED OUTCOMES

It is expected that the findings will highlight significant disparities in UDL awareness, potentially linked to teaching experience. The study aims to uncover how UDL principles are currently being applied in health science education and identify areas where further training or resources are needed. By evaluating educators' knowledge and incorporation of UDL, the study will offer recommendations for enhancing teaching practices and supporting educators in adopting inclusive teaching strategies. Ultimately, the results will contribute to improving student engagement and learning outcomes by fostering more accessible and inclusive educational environments within health science disciplines.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

Based on the evidence gathered, it can be concluded that health science professional educators at the University of the Free State may have varying levels of awareness and understanding of Universal Design for Learning (UDL), with teaching experience likely influencing their familiarity with the framework. This aligns with existing literature that emphasizes the critical role of educator awareness in the successful implementation of UDL. The study's findings may reveal gaps in knowledge, similar to trends observed in other higher education settings. The anticipated conclusions will support the need for targeted professional development and resources to better integrate UDL principles into health science teaching practices, enhancing accessibility and inclusivity for diverse learners.

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Key words : Universal Design for Learning, health sciences, educator awareness

The Student Inner and Interpersonal Growth Assessment (SIIGA): Instrument Development and Evidence for Reliability and Validity

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CONTEXT

The Joint Community Project (JCP) module is a compulsory service-learning experience for 1,650 second-year students in the Faculty of Engineering, Built Environment, and IT at the University of Pretoria. Designed to develop social awareness, teamwork, and civic responsibility, JCP immerses students in hands-on, community-based projects where they apply technical skills while engaging with NGOs, community leaders, and professionals.

Each student completes 40 hours of fieldwork, supported by structured preparation activities. With 350 interdisciplinary teams and over 60 community partners, providing individualised feedback on students' professional development and engagement is impractical. Current evaluation methods struggle to capture nuanced inner (self-awareness, responsibility, and self-regulation) and interpersonal (teamwork, communication, conflict resolution) competencies, making structured assessment of student growth difficult. This highlights the need for a scalable, research-informed instrument tailored to competency development within service-learning contexts.

PURPOSE OR GOAL

Currently, no comprehensive, validated assessment tool exists to reliably measure engineering students' inner and interpersonal growth in large-scale service-learning settings. The JCP module provides a rich but under-assessed context where students develop essential competencies beyond technical knowledge. This study aims to design, implement, and validate a structured framework that captures these professional and interpersonal skills.

The instrument must be scalable and contextually relevant, enabling meaningful feedback in large cohorts without compromising depth or reliability. Our goals are to (1) provide students with structured insight into their growth, (2) offer educators a defensible method for competency evaluation, and (3) contribute a scalable model for broader service-learning environments.

APPROACH OR METHODOLOGY/METHODS

We used a Mixed Methods Research (MMR) approach to develop, refine, and pilot the assessment instrument. Ethical clearance was obtained, and students gave informed consent to use their results for research purposes.

A panel of six subject matter experts (SMEs)—module coordinators, engineering educators, and a psychologist—was assembled. A full-day workshop was held to operationalise eight constructs and plan the item development process. A 360-degree assessment was

designed, including individual, team, mentor, and community partner perspectives. On average, 14 items were developed per construct and refined through several iterations.

A literature review informed item design, incorporating relevant elements from existing instruments where applicable. Two rounds of piloting were conducted per construct, with over 1,000 student responses per round. Data were collected via Blackboard Ultra and analysed using the Rasch Rating Scale model in Winsteps to assess internal reliability and item validity.

ACTUAL OR ANTICIPATED OUTCOMES

The responsibility construct, the first to be piloted, demonstrated minimally acceptable internal reliability (Cronbach's $\alpha = 0.68$) and unidimensionality, indicating a coherent underlying construct. The response scale functioned as intended, with Likert options ordered and increasing monotonically. Only two items showed minor misfit. No significant gender-based differential item functioning (DIF) was detected, suggesting that the items functioned consistently across groups.

These results support the construct's potential validity and the methodological soundness of the design. The findings indicate that the instrument can distinguish levels of perceived responsibility among students in large cohorts. This foundation will guide the refinement of the remaining seven constructs.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

Initial piloting results demonstrate that scalable assessment of inner and interpersonal competencies is feasible within large service-learning modules. The responsibility construct performed reliably, and the development process has shown that it is possible to design instruments that are both psychometrically robust and practically implementable.

The broader goal of the JCP Assessment initiative is to finalise and release the Student Inner and Interpersonal Growth Assessment (SIIGA) as a validated, open-source tool. This will allow institutions to better track and support critical developmental outcomes in engineering students, complementing technical training with structured personal and professional growth.

Future work includes piloting the remaining constructs using self-ratings to refine items and improve internal consistency. We will then develop peer, mentor, and community partner rating versions to enable full 360-degree feedback. Additional plans include testing concurrent validity with project marks and Student Feedback on Teaching Survey (SFTS) data. Content validation will be completed by a second panel of subject matter experts, supported by an expanded literature review.

KEYWORDS

Graduate attributes; Student Inner and Interpersonal Growth Assessment (SIIGA); Mixed Methods Research; Rasch Rating Scale; Instrument validation; Engineering Education

Work-in-Progress: Exploring cultural responsiveness in Engineering Service Learning – A Case Study

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CONTEXT

Higher Education Institutions (HEIs) in South Africa are increasingly prioritising diversity, equity and inclusivity within their curricula (Pérez Foguet et al., 2014; Tampubolon et al., 2023). In engineering education, pedagogical approaches such as service learning (SL) offer opportunities to foster inclusive learning environments, address social inequalities, and promote culturally-relevant engineering solutions (Bowie & Cassim, 2016). However, the integration of cultural responsiveness - which involves acknowledging and respecting diverse cultural backgrounds - remains underexplored in SL programs (Dee & Henkin, 2002; Kiely, 2005). This gap is significant, as SL programs often operate in multicultural communities where understanding cultural dynamics can enhance both student learning and community impact (Mitchell, 2008; Pate et al., 2001). The Joint Community-Based Projects (JCP) module at the University of Pretoria is a large-scale SL initiative designed to develop students' social responsibility and professional competencies. To maximise its impact, further research is needed to explore how cultural responsiveness can be meaningfully integrated into SL programs. This study is informed by Cultural-Historical Activity Theory (Engeström, 1987) and the Second-Generation 3C3R PBL Model (Hung, 2019), which together provide a lens for examining how cultural responsiveness can be integrated into engineering service learning by analysing the interactions between students, mentors, communities, and institutional structures, while also guiding the design of problem-based activities that embed cultural diversity, teamwork and reflection.

PURPOSE OR GOAL

The goal of this study is to explore how culturally responsive practices can be integrated into engineering service learning (SL), particularly within the Joint Community-Based Projects (JCP) module at the University of Pretoria. While SL is widely recognised for fostering social responsibility and professional competencies (Bandy, 2016), its potential to enhance student engagement and community impact through cultural responsiveness remains underexplored (Brown & Howard, 2005). This study aims to investigate how students perceive and navigate cultural differences in SL engagements and initiatives, the challenges and opportunities of implementing culturally responsive approaches, and how engineering SL programs can be adapted to foster more inclusive and equitable learning experiences. The research seeks to provide insights that can inform the design and assessment of SL curricula, ultimately contributing to the development of socially responsible and culturally competent engineering graduates.

APPROACH OR METHODOLOGY/METHODS

This study will adopt an exploratory case study design to investigate cultural responsiveness in engineering service learning (SL). The research will focus on the Joint Community Projects (JCP) module at the University of Pretoria, engaging key stakeholders including students, lecturers, mentors and community partners. Data will be collected through qualitative methods such as focus groups with students and mentors to explore perceptions and lived experiences of cultural engagement, and semi-structured interviews with lecturers and community partners to identify challenges, benefits and effective implementation practices. Document analysis and observational data from module activities will also be incorporated to enrich contextual understanding. Thematic analysis will be used to identify recurring patterns and generate insights across stakeholder perspectives. Findings from this study aim to inform the development of evidence-based guidelines and pedagogical strategies for integrating cultural responsiveness into SL curricula in engineering education.

ACTUAL OR ANTICIPATED OUTCOMES

Although the study is ongoing the following outcomes are anticipated. These include the identification of key challenges students face in navigating cultural differences in service learning (SL) contexts, and insights into how cultural responsiveness influences student engagement, learning experiences, and both academic and community outcomes. The research is expected to inform the development of evidence-based guidelines for integrating cultural responsiveness into SL initiatives. It will also offer recommendations for curriculum adjustments that promote inclusive and equitable learning environments. The findings are expected to highlight the importance of structured interventions in ensuring that engineering SL programs not only develop technical and professional skills, but also support the development of cultural competence. Ultimately, the study aims to provide practical guidelines for educators, institutions and policymakers seeking to enhances the effectiveness and inclusivity of SL in engineering education.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

As this study is still in the early stages, definitive conclusions have not yet been established. However, it is anticipated that the findings will offer valuable insights into how cultural responsiveness can enhance student engagement, learning experiences and both academic and community outcomes within engineering service learning (SL). This research seeks to inform practical recommendations for engineering educators seeking to design and implement more inclusive and culturally responsive SL programs. By addressing an underexplored dimension of SL, this research hopes to contribute to broader efforts to diversify engineering education and improve the relevance and effectiveness of SL experiences to strengthen its societal relevance. Future research may also extend these insights to broader educational contexts, to further understand the role of cultural responsiveness in shaping transformative learning experiences.

KEYWORDS

Service Learning, Cultural Responsiveness

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A Phenomenological Analysis of Social Justice and Well-Being in the Education System

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CONTEXT

The challenges faced by South African learners highlight deep-rooted inequalities within the education system, where socioeconomic hardships, mental health struggles and limited access to resources create significant barriers to academic success. The education system in South Africa required a drastic change post-1994 with a focus on equity and social justice. Thus, in its "Plan of Action", the Department of Education provided plans to redress social justice, equality and access issues with one proposal discussing the dissuasion of charging school fees for poverty-stricken schools (Mestry & Berry, 2016). The quintile ranking system model was developed to remove the burden of paying for school fees amongst families that could not afford to do so. However, it has turned the education system into a competitive market with quality education as a commodity (Maistry & Africa, 2020). This has resulted in parents relocating their children from rural and township schools to urban area schools, while urban families opt for private schools (Mestry & Berry, 2016). These changes outline how a market-driven education system has been created over the years.

PURPOSE OR GOAL

Education is a constitutional right; however, socioeconomic disparities continue to hinder access for all learners in South Africa. The absence of social justice results in inequality in education, with scholars concluding that the right to education can assist an individual in achieving other fundamental rights because education is an enabling factor, especially for those from poor socioeconomic backgrounds (Munongi, 2023). The commodification of quality education in South Africa has been well-documented, with studies highlighting how the quintile system and unequal funding structures have transformed education into an economic good (Maistry & Africa, 2020). However, there is a notable gap in the literature on how to counteract this phenomenon. The purpose of this study is to explore the lived experiences of learners and teachers in urban and rural South Africa to understand how social justice disparities manifest and are experienced. This is to establish a baseline to inform initiatives aimed at enhancing the South African education system.

APPROACH OR METHODOLOGY/METHODS

This study employs a phenomenological approach to examine the lived experiences of learners and educators concerning social justice and well-being in South African schools. It is argued that this methodology can grasp the dynamic, ambiguous and complex phenomena of what it means to live and receive an education in this society (Kim, 2012). Phenomenology is ideal, as it emphasises subjective experiences within socio-educational contexts. Data collection will be through interviews of participants from different backgrounds and supported by an extensive literature review, incorporating case studies to analyse real-world applications of social justice in education. By reviewing documented experiences and conducting interviews with those within the education system, this method aims to challenge existing

literature findings or identify recurring patterns, challenges and themes in educational inequalities, such as the commodification of education, highlighting how these disparities impact learner well-being and social justice.

ACTUAL OR ANTICIPATED OUTCOMES

This study anticipates uncovering persistent social justice disparities in South Africa's education system, particularly between urban and rural schools. It is expected to highlight how funding inequalities and resource shortages negatively impact learners' mental, emotional and academic well-being. The commodification of education could be shown to limit access to quality learning, further reinforcing systemic inequalities. It's also expected that recurring themes in learners' and educators' experiences will likely emerge, offering insights into adaptation strategies and challenges. Additionally, the study could identify effective strategies and interventions to address these disparities to inform policies and teaching practices that promote accessibility to quality education, ensuring that disadvantaged communities receive the necessary tailored support for better educational experiences and outcomes.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

This study aims to emphasise how social justice and learner well-being are affected by economic inequalities. The findings will assist in developing tailored reform strategies to promote inclusive education and bridge the disparities, such as the difficulties in mathematics teaching and educator quality, amongst others, which are also addressed in a recently published paper by Thabang Ngwenya and Pabalelo Chaba titled "Mathematics Education in South African (Grades 1-12): A Systems Dynamics Approach from an Engineering Education Perspective". Lastly, to bridge these gaps, targeted interventions that are small yet impactful, such as policy changes, should prioritise interventions such as teacher training and the equitable distribution of resources, ensuring that learners from disadvantaged backgrounds receive optimised support, promoting greater social justice and inclusivity.

KEYWORDS

Social justice, educational inequality, phenomenological analysis

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Design of orientation week activities to foster a sense of belonging for engineering students: Work-in-Progress

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CONTEXT

The significant drop-out rate of first year engineering students in South African higher education institutions (HEIs) continues to be a concern (Fraser, 2024). This can partially be attributed to the difficulties students experience in transitioning from school to university. HEIs address this by designing first year experience programs such as orientation week. This study forms part of a larger project investigating how orientation week programs foster a sense of belonging for female engineering students. Several studies have indicated that creating opportunities for students to connect with their peers and academic staff, and to feel that they are part of the university community has the potential to help first year students, especially underrepresented students succeed (Montague et al., 2024, Mugume 2022, Ning et al., 2021).

PURPOSE OR GOAL

The purpose of this part of the study is to explore the design of orientation week activities from the perspective of staff involved in orientation week. We will investigate the extent to which the design is informed by developing and enhancing students' sense of belonging. Lizzio (2006) identifies "five senses of success" which students need during their first weeks at university. These include students' senses of (1) capability, (2) connection, (3) resourcefulness, (4) purpose, and (5) academic culture.

This paper will address the following question: In what ways are orientation activities designed to foster belonging for engineering students?

APPROACH OR METHODOLOGY/METHODS

The study uses a qualitative approach. We will conduct in-depth semi-structured interviews with purposively selected staff at several South African engineering universities using the five senses of success framework (Lizzio, 2006) to understand their experiences of designing and implementing orientation programmes. The collected data will be analysed through thematic (Braun & Clarke, 2006) and discourse analysis (Godman, 2017).

ACTUAL OR ANTICIPATED OUTCOMES

We expect to identify the ways in which staff design orientation week activities to create and enhance a sense of belonging for students, and to set them on a trajectory for success. We expect to explore the priority which is given to the different senses of success, and the reasons that lie behind this. We will learn about the challenges which orientation week staff encounter, and potential improvements which they intend to implement.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

The results from this study will allow comparison between different universities' orientation week activities according to how different senses of success are prioritised and developed. Staff feedback will also contribute to a conversation about the applicability of the Lizzio framework in a South African context. The context of orientation week design will inform future project activities, which will focus on students' experiences of orientation week.

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KEYWORDS

Orientation week, Sense of belonging, Lizzio's five senses of success

Defining the responsibilities of engineers: A conceptual framework

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CONTEXT

Responsibility is a core concept for engineering ethics (Herkert, 2002), prominently featured in professional codes of practice, accreditation requirements for graduate engineers, and the mission statements of engineering programmes and technological universities. Yet, it is often used ambiguously, as responsibility can refer to numerous obligations, at varying degrees and toward different parties, making it challenging to clearly define the concept (Johnson, 1992, p.21). As technology advances and societal expectations shift, there is an increasing need for engineers to consider the ethical dimensions integral to engineering practice. Given that the mission statements of engineering higher education institutions, accreditation requirements and engineering professional codes emphasise responsibility, it is important to have a comprehensive, structured approach that encompasses its dimensions.

PURPOSE OR GOAL

Given the pivotal role that responsibility plays in engineering practice and the challenges faced by engineering programmes in rendering the full range of ethical expectations and implications of engineering work (Hess & Fore, 2018; Martin, Conlon, & Bowe, 2021), it is important to clarify and disambiguate the concept to provide a more structured and comprehensive articulation supporting its integration in engineering education. This research aims to advance the understanding of what are the responsibilities of engineers by surveying existing interpretations within the engineering ethics literature and synthesizing these into a cohesive conceptual framework.

APPROACH OR METHODOLOGY/METHODS

Using a narrative literature review, the study synthesizes the engineering ethics literature to develop a conceptual framework that articulates a broad spectrum of engineering responsibilities. Articles included in the review were selected based on relevance to engineering ethics, focus on responsibility, and publication in peer-

reviewed journals. Interdisciplinary sources, particularly in engineering education, were incorporated when they provided valuable insights into ethical responsibilities. The analysis followed Saldaña's (2016) thematic approach to identify recurring themes and patterns in the understanding of responsibility in engineering ethics. These insights were synthesized and structured to develop a conceptual framework that provides a comprehensive articulation of responsibilities for engineers.

The article builds on the distinctions developed by Herkert (2005), Conlon (2011), and Conlon et al (2018) to articulate and structure formulations of engineers' responsibilities This framework categorizes engineering responsibilities emerging from the engineering ethics literature at four analytical levels (Micro/Macro and Subject/Object).

ACTUAL OR ANTICIPATED OUTCOMES

The study puts forward 16 responsibilities, which I hope to brainstorm with participants. Micro-Subject responsibilities include identifying and accounting for the immediate consequences of one's actions, developing and enacting specific character traits and virtues, upholding ethical standards, and complying with legislation. Micro-Object responsibilities include contributing to workplace conditions for ethical and sustainable practice, opposing the unethical actions of managers or colleagues, acting as a workplace ally for minority colleagues, opposing work for/of employers active in unsustainable industries or that endanger human rights. Macro-Subject responsibilities include foreseeing and accounting for the long-term consequences of technological developments, reflecting on the values guiding engineering practice, developing technology for the public good on local and global scales, and including stakeholders in technological innovation and exnovation. Macro-Object responsibilities include developing policies, laws and regulations to improve engineering practice and engineering applications, engaging in collective activism against unethical engineering practices or toward ethical engineering practice, engaging in reforming industries that are unsustainable or endanger human rights, values and lives on local and global scales, and engaging in reforming the engineering profession beyond the sole pursuit of technological development.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

This framework provides a practical tool for engineering curriculum development and accreditation processes by providing clear formulations for setting learning objectives and graduate attributes that support the embedding of responsibility across the curriculum and across accreditation requirements. In engineering education research, the framework provides a terminology for developing new assessment tools to measure students' and professionals' understanding of their responsibilities.

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KEYWORDS

Engineering ethics; responsibility

Spatial design for embodied participation in Higher Education

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CONTEXT

The United Nations' Sustainable Development Goals require countries (and universities) to ensure equal access to higher education through widening participation. This is explicitly formulated in Sustainable Development Goal 4 (4.3: Equal access to technical, vocational and higher education). Broadened access should include not just physical admission, but also meaningful engagement with the knowledge-making practices of the university. Increasingly, it is acknowledged that traditional pedagogical genres such as lectures and tutorials may no longer be the most effective way of fostering student learning. These traditional genres can lock people into traditional academic practices, which may stifle diverse ways of knowing and being in higher education. Recent educational research, especially that from the global South, has shown that there are many paths towards active engagement and inclusion of students' knowledges, practices and identities.

PURPOSE OR GOAL

This presentation investigates how social, material and embodied practices are realized in the design of one programming course in a university in Sweden. We show how spatial resources can be harnessed to create environments that foster embodied forms of student engagement. We further demonstrate how this process is mediated through the intentional coordination of a range of physical and digital artefacts in the classroom. These artefacts include flexible whiteboards, curtains and tables. In so doing, our aim is to show how (re)design of the genres of teaching and learning in higher might enhance access to the knowledge-making practices privileged within the discipline – in this case, programming.

APPROACH OR METHODOLOGY/METHODS

The study makes use of a multimodal ethnographic case study design. This combines ethnographic analysis of educational practices with analysis of texts and other semiotic artefacts and resources. Data was collected through individual and group interviews with teachers, as well as through observation and recording of two classes in their full length (each two hours). Photos were taken, and course documentation was collected. All the data was collected in Sweden and transcribed before being translated into English. Analysis of the ethnographic data was then matched with analysis of the spatial design of the seminar room, including key artefacts present therein.

ACTUAL OR ANTICIPATED OUTCOMES

We show how a pedagogy of participation is enacted in the programming classroom. This is achieved through the spatial design of the classroom itself, which affects the ways that students engage. Furthermore, material resources (such as furniture) are coordinated to foster embodied engagement and participation amongst students. Crucially, the privileging of analogue tools in the classroom for what is traditionally conceived of as a digital practice is an interesting strategy for increased participation amongst students with differing degrees of

background knowledge about programming. This strategy involves students solving programming tasks, but as part of a group in which agency is shared among the participants. The discursive agency of digital tools is managed through materially limiting their use.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

We offer a discussion of the implications of our findings for what we call a pedagogy of participation; such a pedagogy combines a focus on collaboration, de-digitalization, and embodiment, through spatial design and coordination of the material-discursive. Our hope is that such pedagogies, as shown through our exploration of the spatial and material resources employed in this particular context, offer a lens to enhance inclusion of students with diverse backgrounds and knowledges.

KEYWORDS

Higher education pedagogy, student engagement, spatial design