CREATE-ing New Perspectives: A Transformative Learning Approach to Sustainability in First-Year Engineering Education

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Abstract

This paper examines how integrating challenge-based/problem-based learning (CBL/PBL) with creative expression triggers perspective transformation in first-year engineering students' understanding of sustainability. The Crafting Resourceful Engineering and Artistic Transformations for Education (CREATE) project, framed by Mezirow's Transformative Learning Theory, used artistic creation as a disorienting dilemma to challenge preexisting assumptions about engineering's role in sustainability while developing ECSA Graduate Attributes.

Funded by South African Society for Engineering Education (SASEE), the project engaged students with SDGs through four interconnected assessments: individual essays and presentations, group artistic artifacts and TikTok videos. First-year engineering students consulted with a Fine Arts student on project designs, creating interdisciplinary collaborations that challenged traditional engineering paradigms.

Longitudinal survey data revealed evidence of perspective transformation aligned with Mezirow's theory. Students progressed from viewing sustainability as isolated technical problems to understanding it as interconnections between society, technology, and environment. This shift was evident in their enhanced ability to communicate technical concepts while considering broader societal implications—a key indicator of transformative learning in engineering education.

Keywords: Transformative Learning, Sustainability, Challenge-Based Learning, Creative Expression

1 Introduction

Engineering education faces growing pressure to prepare graduates capable of addressing complex sustainability challenges. However, Graham (2021) and Bryne and Mullally (2016) remind us that traditional engineering curricula often emphasise technical problem-solving skills while giving less attention to the broader societal, environmental, and ethical dimensions of engineering practice. This disconnect creates a gap between technical education and the interdisciplinary thinking required to address pressing issues such as waste management, resource depletion, and environmental degradation. The challenge is particularly relevant in the South African context, where engineering solutions must navigate complex socio-economic realities while addressing urgent sustainability needs. Engineering Council of South Africa (ECSA) recognises this through Graduate Attributes that extend beyond technical competence to include communication capabilities, interdisciplinary collaboration, and professional ethics (Gwynne-Evans, Chetty & Junaid 2021). However, effective pedagogical approaches for developing these broader attributes while fostering deep understanding of sustainability remain underexplored.

Funded by the South African Society for Engineering Education (SASEE), the Crafting Resourceful Engineering and Artistic Transformations for Education (CREATE) project embedded creative expression within a year-long communications course, aligning with five ECSA Graduate Attributes: Investigations, experiments and data analysis (GA4), professional and technical communication (GA6), individual, team and multidisciplinary working (GA8), independent learning capability (GA9), and engineering professionalism (GA10). Students engaged with Sustainable Development Goals (SDGs) through four interconnected assessments: two individual (an oral presentation and an essay) and two group-based (an artistic artifact and a TikTok video).

The novelty of this approach lies in its intentional use of creative expression not merely as an engagement tool but as a catalyst for perspective transformation. By requiring students to translate technical knowledge about waste management into artistic artifacts and digital media, the project challenged traditional engineering communication norms and created opportunities for students to reconsider fundamental assumptions about engineering practice, sustainability, and their professional identities.

2 Background

The CREATE project was implemented in a first-year communications class (Professional Communication – course code PCM150X) for the extended curriculum Industrial Engineering Diploma (ECP) at Cape Peninsula University of Technology. This year-long course, which typically covers foundational communication skills including the origins of communication, presentation techniques, writing support, and conflict management, became the setting for an innovative approach to engineering education. Of the 39 registered students, 35 actively participated throughout the course, with four withdrawing early from the course.

At the beginning of the academic year, students were introduced to the broad concept of waste beneficiation as an organising theme for the year course. The project took a significant turn during the second term when an opportunity arose to collaborate with Engineers Without Borders South Africa (EWB-SA) and the Integrated Engineering Curricula (IEC) team. This partnership enabled the communication students to participate in a pilot local design challenge focused on sustainability issues in Cape Town townships, specifically the Dunoon township.

EWB-SA and the IEC team developed a comprehensive design challenge supported by extensive resources: a high-quality informative video about Cape Town townships that contextualised the socio-economic and environmental challenges; municipal data including road and traffic information, maps, and details about local facilities; and comprehensive information about the United Nations Sustainable Development Goals (SDGs). To build on these resources, students received a dedicated lesson on the SDGs to establish a sustainability framework for the project, participated in four facilitated design thinking sessions to help

student groups conceptualize their designs, and accessed support from the institutional writing centre to strengthen their writing processes.

Through consultation with students, four interconnected assessments were developed to comprise the final evaluation (contributing 40% of the course grade). These included two individual components—an oral presentation where students presented their understanding of the design challenge and proposed solutions in relation to the SDGs, and a 2,500-word essay that elaborated on the concepts presented in the oral presentation. The remaining two assessments were group-based: an artistic artifact made from waste materials supplemented with art supplies, and a TikTok video that presented the design solution in a digital format. This structure balanced individual accountability with collaborative creation, with students receiving formative feedback on draft versions of their individual submissions to support their learning and development.

The integration of artistic expression through both physical artifacts and digital media was deliberately designed to challenge traditional engineering communication norms and potentially trigger perspective transformation regarding engineering's role in addressing sustainability challenges. This approach aligned with the development of ECSA GAs, while the principles of Mezirow's Transformative Learning Theory, creating opportunities for students to reconsider fundamental assumptions about engineering practice and sustainability.

3 Transformative learning theory in Engineering Education

The foregoing scenario serves as a case study to illustrate how Jack Mezirow's transformative learning theory (Mezirow, 1997, 2010) can provide a framework for understanding the notable shifts in professional practice comprehension experienced by engineering students through CBL/PBL. This approach is particularly pertinent in the context of contemporary engineering education in South Africa, where the cultivation of generic competencies such as leadership, teamwork, and cross-cultural competence is imperative due to the requirements of ECSA (GA 6 to GA11).

Mezirow's influential framework has been widely adopted, adapted, and examined by scholars over time. From early interpretations (Christie, 2003) to more recent applications researchers (Shandilya, Yoon, Raju, & Kwuimy 2023; Beckett, 2018; Sahin Izmirli & Kabakci Yurdakul, 2014), have engaged with the framework's ten stages: (1) disorienting dilemma, (2) self-examination, (3) critical assessment, (4) recognition, (5) exploration, (6) planning a course of action, (7) acquisition of knowledge, (8) provisional trying of new roles, (9) building of competence and self-confidence, and (10) reintegration. Moreover, Nohl (2015) offers a valuable synthesis of these stages, condensing them into five phases: (1) a nondetermining start, (2) a phase of experimental and undirected inquiry, (3) a phase of social testing and mirroring, (4) a shifting of relevance, and (5) social consolidation and the reinterpretation of biography. This restructuring presents a more streamlined yet comprehensive model for assessing transformational learning processes.

Furthermore, this framework resonates with Paulo Freire's assertion in his seminal work on problem-posing education, where he states: "*In problem-posing education, people develop their power to perceive critically the way they exist in the world with which and in which they find themselves; they come to see the world not as a static reality, but as a reality in process, in transformation*" (Freire, 1970: 83). Freire's perspective highlights the dynamic and transformative nature of education—a concept that is consistent with Mezirow's theory, reinforcing the transformative potential of PBL in engineering education.

4 Praxis

This study employed a longitudinal approach, conducted from July 2024 to March 2025. Mixed data was collected at three intervals through surveys administered in July 2024, October 2024, and February 2025, capturing student perspectives at the beginning, conclusion, and several months after the project. The project commenced when first-year Industrial Engineering students in the Professional Communication

course (PCM150X) were introduced to the Dunoon township case study developed by EWB-SA in July 2024. Students were organised into project teams and guided through a structured 12-week process that integrated engineering design thinking with artistic expression.

The pedagogical approach followed a carefully sequenced progression over eleven weeks, beginning with contextual immersion and empathy-building exercises in which students examined video documentation of Cape Town townships. They then conducted simulated stakeholder interviews to develop engineering communication competencies. This foundation was followed by theoretical framing through SDGs alongside practical problem identification exercises, reinforced by team-building activities centred on conflict management and negotiation. By week five, students collaboratively established assessment criteria, resulting in four interconnected tasks (individual essays and oral presentations, group artistic artifacts, and TikTok videos) while receiving supplementary municipal data from the EWB-SA website. The middle phase focused on problem definition refinement using root cause analysis techniques, followed by academic writing development with institutional writing centre support and formative feedback on drafts. The sequence culminated in an artistic workshop facilitated by a second-year Fine Arts student—funded through a SASEE grant—before students submitted their final assessments in a staggered schedule spanning the first week of October.

4.1 Data Collection and Analysis

Data were collected through three online surveys (n=12 in July 2024, n=21 in October 2024, and n=4 in February 2025). The survey instrument incorporated Likert-scale questions and open-ended responses to obtain comprehensive insights and track students' perceptions of their learning experience. Internal validity of the Likert-scale items was verified using Cronbach's alpha coefficient. Quantitative data were analysed using SPSS to explore five constructs aligned with transformative learning theory: (1) a non-determining start, (2) a phase of experimental and undirected inquiry, (3) a phase of social testing and mirroring, (4) a shifting of relevance, and (5) social consolidation and reinterpretation of biography. Qualitative data from open-ended survey questions underwent thematic analysis to identify recurring patterns. To mitigate potential bias, the analysed data was reviewed by a colleague not involved in the research project. The research was conducted with appropriate ethical oversight, with institutional ethics clearance granted (certificate 2024FEBEFREC-ST-13).

5 Results and Discussion

The participants' feedback on the use of creative and unconventional methods (the art projects and TikTok) suggests these approaches enhance engagement and made learning more interesting and relevant. Students reported greatly valuing the integration of creative projects for conceptualising complex engineering challenges in new ways. One participant noted, *'The TikTok project made me think differently about how to communicate technical concepts to a broader audience.*' Another highlighted, *'Working on the art project helped me realise the real-world impact of waste management technologies.*'

An additional insight derived from data analysis was that participants frequently mentioned the development of graduate attributes and reflected on their future professional roles and responsibilities. This suggests that the project was effective in helping students envision themselves as future engineers who are ethically responsible and sustainability-oriented. These responses underscore a significant shift in relevance, from viewing engineering as purely technical to appreciating its societal implications. Participants also reflected on the social aspects of learning, emphasising the importance of collaboration and communication skills they developed through group-based activities.

From the analysis of initial (benchmark) survey in July 2024, it was observed that at the outset, students had varied levels of confidence across key competencies such as presenting technical information, writing technical reports, and working in teams. This initial variance, as well as the anxiety participants reported highlights the diverse background and skills set the students brought to the course. Essentially, it set a

baseline for the transformative journey. This aligns with Mezirow's 'disorienting dilemma', 'self-examination' and 'critical assessment' stages, or Nohl's (2015) 'nondetermining start'.

Subsequent analysis of the second survey data in October 2024, highlighted that the integration of creative components such as art projects and TikTok videos served as catalysts for experimental learning. Participants expressed that these activities made learning more interesting and enjoyable, suggesting an initial engagement that prompted deeper inquiry into both technical content and collaborative processes. The general view expressed by participants was that this pivotal in allowing students to explore concepts and ideas beyond traditional engineering education paradigms. This is consistent with Mezirow's 'recognition' and 'exploration' stages or Nohl's (2015) phase of 'experimental and undirected inquiry'.

The second survey data also suggests that as the course progressed, students reported increasingly engaging in teamwork and leadership roles, evidenced by improved confidence in leading group discussions and working collaboratively on complex projects. The feedback from peers and instructors during these activities provided critical social testing, where students could mirror professional behaviours and refine their interpersonal and technical skills. Thus, it may be deduced that this constituted 'planning a course of action', 'acquisition of knowledge' and 'provisional trying of new roles' in Mezirow's framework or 'social testing and mirroring' phase in Nohl's (2015) framework.

Finally, survey 2 data also implies that as the course progressed, there was a noticeable shift in how students valued their role in addressing sustainability through engineering. This was reflected in their growing confidence in proposing sustainability elements to complement engineering solutions and their enhanced understanding of the socio-environmental impacts of engineering decisions. The relevance of interdisciplinary skills became more apparent, aligning students' learning with the broader goals of sustainable development. It is believed that this represents 'building of competence and self-confidence' of Mezirow's framework or 'shifting of relevance' of Nohl's (2015) framework.

Finally, the analysis of the third survey indicated that by the end of the project, many students reinterpreted their professional identities (as an engineering student) and also recognised their future potential impact as engineers committed to sustainable practices. This is consistent with Mezirow's final stage 'reintegration' or Nohl's (2015) 'social consolidation and the reinterpretation of biography' phase.

6 Main challenges, lessons learned and future perspectives

The inception of this project was characterised by a lack of a predefined plan, which subsequently evolved through collaborative efforts with a subgroup of the IEC team and EWB-SA. The project's structure and objectives crystallized progressively as it unfolded. This iterative development process, while marked by considerable uncertainty, proved effective as indicated by the research data, which suggests that the project achieved meaningful results. During the project execution however, several areas were identified that could benefit from improvement. Notably, the project rubrics, initially developed collaboratively with students during the course, were refined following the initial formative assessments. This experience highlighted the importance of providing students with well-defined rubrics at the commencement of the course to better guide their learning and expectations. For future iterations, it is recommended to establish and share rubrics upfront to enhance the clarity and effectiveness of assessments

7 Limitations

Several limitations must be acknowledged. The small and declining sample sizes across data collection points (n=12, n=21, n=4) severely limit generalisability, particularly the final survey with only four participants. The study's implementation within a Professional Communication course, while providing flexibility for creative expression, raises questions about transferability to core technical engineering subjects where curriculum constraints and pedagogical norms differ significantly. Additionally, the focus on Industrial Engineering students within an extended curriculum program may limit broader applicability to traditional first-year

engineering cohorts across diverse disciplines. The resource-intensive nature of the intervention, requiring specialized partnerships, art supplies, and facilitation support, presents scalability challenges for implementation in different institutional contexts. Future research should examine larger samples, explore adaptations for technical courses, and investigate resource-efficient implementations across diverse engineering disciplines.

8 Acknowledgments and funding

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9 Conclusion

The CREATE project demonstrates how transformative pedagogies can be integrated into existing engineering curricula through embedding transformative learning opportunities within a required communications course and connecting them to real-world sustainability challenges. By leveraging artistic expression as a disorienting dilemma, the project successfully triggered perspective transformation in first-year engineering students' understanding of sustainability concepts, as evidenced by the longitudinal survey data collected over nine months.

This study confirms that the integration of CBL and PBL with creative expression provides a powerful mechanism for facilitating the phases of transformative learning. Students progressed from a non-determining start through experimental inquiry and social testing, ultimately experiencing a shifting of relevance and social consolidation that transformed their understanding of engineering's role in addressing sustainability challenges. The four interconnected assessments—particularly the artistic artifacts and TikTok videos—served as catalysts for this transformation, challenging traditional engineering communication norms while simultaneously developing key ECSA Graduate Attributes.

Ultimately, the findings of this study aligns with Mezirow's assertion that "*it is not so much what happens to people but how they interpret and explain what happens to them that determines their actions, their hopes, their contentment and emotional well-being, and their performance*" (1997, p. xiii). Through the CREATE project, students became active agents in their own transformation, supported by a carefully structured pedagogical approach that provided opportunities for critical reflection on assumptions about engineering practice and sustainability. Students' progression from viewing sustainability as isolated technical problems to understanding it as a complex web of interconnections between society, technology, and environment represents exactly the kind of perspective transformation needed in contemporary engineering education.

This research contributes to engineering education practice by demonstrating a concrete, implementable approach to developing both technical competencies and broader professional attributes through transformative learning experiences. The CREATE project thus offers a promising model for engineering educators seeking to prepare graduates capable of addressing complex sustainability challenges through integrated socio-technical understanding.

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