Integrating Language and Communication Skills into Engineering Education: A Conceptual Reference Model for Effective Collaboration and Learning

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Abstract—**This article proposes a framework for integrating language and communication skills (LCS) into engineering education to address the growing demand for engineers with strong social responsibility, global engagement, and effective communication skills, alongside technical expertise. The study highlights the challenges associated with integrating LCS into engineering curricula, including student perception and curriculum demands. It emphasises the importance of contextualising LCS within engineering and references inductively formulated guiding principles for their integration. A reference model, built upon these principles and the Community of Inquiry (CoI) framework, is presented. The CoI framework emphasises cognitive, social, and teaching presence, aligning with the potential benefits of integrating LCS. The model outlines strategies for fostering each presence within the learning environment. The study concludes by advocating for the proposed framework as a practical roadmap for educators and curriculum designers. This framework equips future engineers with the essential LCS necessary for success in the 21st century, fostering critical thinking, inclusivity, and collaboration through language.**

Keywords— **Communication Skills; Community of Inquiry framework; Engineering Education; Integration**

JEET Category—**Research**

I. INTRODUCTION

Higher education is tasked with the responsibility of training engineers equipped with a diverse range of skills suited to a dynamic world of interdisciplinary endeavour and transformation. Globalisation has made collaboration across geographical borders ubiquitous and inevitable, highlighting the need for an engineering graduate to possess the competencies required to interact with a diverse array of stakeholders, present ideas clearly, and ensure that high ethical standards are maintained. Without adequate language and communication skills, a new graduate will be found wanting when engaging with the ideas of others as well as when expressing his or her own. Effective communication skills scaffold responsible decision-making and promote ethical practices within the field of engineering (Klein-Gardner & Walker, 2011; McGunagle & Zizka, 2020). These skills are among those considered transversal and are essential for technical professionals to address ethical and social concerns. They enable engineers to articulate the potential impact of their projects on society, engage in ethical discussions, and communicate the risks and benefits associated with engineering solutions (Weichert, Rauhut & Schmidt, 2001; Winberg, Bramhall, Greenfield, Johnson, Rowlett, Lewis, Waldock, & Wolff, 2020).

There can be little doubt that graduates equipped with adequate language and communication skills will be at a competitive advantage when they enter the job market. Effective communication skills enable engineers to engage with clients and understand their needs, gather requirements, and convey technical information in a way that is accessible to non-technical stakeholders. Skilful communication enhances client satisfaction, builds trust, and strengthens professional relationships.

Despite the acknowledgement that an engineer, who merely possesses technical skills, will soon be found wanting in an era that places a premium on social responsibility and global engagement, some engineering students fail to see the direct relevance of language and communication skills to their field of interest. In a demanding curriculum, with a wide range of technical modules to cover, they often perceive a language and communication module as a superfluous burden that detracts from their core focus (Spoelstra & Collins, 2023). These students often lack awareness of the potential impact that effective communication can have on their career advancement, teamwork, client interactions, and project success. This typically leads to a dismissive attitude towards the module which may be exacerbated by a belief that these skills are either

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present naturally or acquired through personal experiences, rather than through structured learning. Addressing these concerns requires contextualising the importance of language and communication skills within the engineering profession. The integration of the learning outcomes associated with a language and communication skills module into the broader technical curriculum of an engineering programme is likely to improve perceptions of relevance and assist in preparing well-rounded engineering graduates. For this integration to be successful, however, challenges related to cross-disciplinary collaboration, information sharing, and differing perspectives will have to be addressed. What is needed is a common framework that would facilitate effective interdisciplinary collaboration, knowledge sharing, resource sharing and collaborative decision making.

This study proposes a reference model that is based on inductively formulated guiding principles concerning how best to integrate language and communication skills into engineering education. Given the collaborative and multidisciplinary nature of integrating language and communication skills into a technical program, along with the intersections of cognition, social interaction, and instruction, the conceptual reference model is articulated using the principles and guidelines found within the CoI framework. This framework places emphasis on the cognitive presence, social presence and teaching presence as characteristics of an educational endeavour.

II. CONCEPTUAL FRAMEWORK

Engineering education stands at a crossroads, grappling with the evolving demands placed on engineers in our interconnected world. These demands have transcended the boundaries of traditional technical expertise, ushering in an era where a broader spectrum of skills is imperative. As the engineering profession navigates this transformative phase, two critical focal points emerge: the pivotal role of language and communication skills and the pressing need for an integrative approach within engineering education. These facets are at the forefront of preparing professionals for a world that is increasingly interconnected and complex.

A. transversal skills and the modern engineer

In the contemporary landscape of engineering education and practice, the role of an engineer has evolved beyond technical expertise alone. The ideal engineer’s profile, often referred to as the "Renaissance Engineer," underscores the imperative for engineers to possess a broad spectrum of transversal skills. These skills encompass not only high technical competence but also proficiency in language, cross-cultural communication, leadership abilities, ethical awareness, creativity, and an understanding of the intersection between technology and social development (Weichert, Rauhut & Schmidt, 2001; Caeiro-Rodríguez et al., 2021). In parallel, the concept of a "Global Engineer" further accentuates the importance of interdisciplinary knowledge, intercultural competences, and the ability to address global challenges (Aponte, Agi & Jordan, 2017).

B. LANGUAGE AND COMMUNICATION SKILLS, CULTURAL AWARENESS, AND THE GLOBAL ENGINEER

Language and communication skills stand out as quintessential transversal competencies essential for the modern engineer (Del Vitto, 2007). Beyond the technical realm, engineering graduates are required to possess the ability to function effectively in complex interpersonal settings and navigate cross-cultural interactions. Proficiency in English is imperative for fostering global communication and collaboration in the increasingly global field of engineering (Riemer, 2002; Winberg et al., 2020). The demand for engineering graduates equipped with not only technical prowess but also soft skills reflect the evolving landscape of engineering careers and the necessity for engineers to serve as "knowledge workers," "culture surfers," and adept "networkers" (Weichert, Rauhut, Schmidt, 2001).

C. overcoming challenges through interdisciplinary collaboration

Engineering education faces challenges in aligning with the multifaceted demands of the profession. While educational systems excel in producing specialised engineers with robust technical knowledge, they often fall short in cultivating cross-cultural experience, language skills, interpersonal competencies, and an understanding of leadership and management principles. These deficiencies often leave graduates ill-prepared to address the demands of the modern engineering landscape (Winberg et al., 2020).

Interdisciplinary collaboration emerges as a solution to many of these challenges. Industry collaboration, global exposure, and cooperative efforts between faculties within universities can foster a collaborative environment and enhance the acquisition of transversal skills, such as communication skills, among students. This collaborative approach bridges the gap between theoretical knowledge and practical application, preparing engineering graduates for the complex and evolving demands of the professional world (McGunagle & Zizka, 2020; Riemer, 2002). It is through such collaboration that genuine changes can be instigated in engineering education, aligning it with industry and societal demands (Costello, Brown, Butler, et al., 2022).

D. a move toward an integrative approach

Addressing the evolving requirements of engineering education necessitates an integrative approach. This approach involves incorporating transversal skills, particularly language and communication, into the engineering curriculum (Martins, Freitas, Direito & Salgado, 2021). It entails integrating social science and communication subjects throughout the curriculum to reinforce oral and written communication skills, critical analysis, and cross-cultural competence. Moreover, the assessment structure should reflect the importance of these skills, encouraging their application and reinforcing desired behaviour (Costello, Brown, Butler, et al., 2022).

An integrative approach also encompasses redefining the engineering educational paradigm by exploring possibilities for collaboration within engineering education and creating interdisciplinary options and programmes. This shift combines traditional teaching methods with contemporary elements that emphasise the characteristics of the global engineer, ultimately preparing graduates who are equipped to thrive in the dynamic and interconnected world of engineering (Winberg et al., 2020).

III. RESEARCH METHODS AND DESIGN

The aim of this study was to formulate a reference model intended to function as a framework for seamlessly integrating language and communication skills into engineering education. The guiding principles underpinning this reference model were derived through an inductive process, employing an iterative design-based research approach. To refine these principles, a thorough examination of pertinent literature was undertaken to identify prevalent themes, patterns, and relationships. This reflection served to consolidate and integrate diverse perspectives into a cohesive conceptual framework upon which a reference model could be based.

A. Inductive Phase

During the inductive phase of the research, a purposively selected design team was exposed to a tentative strategy or set of ideas regarding how the learning outcomes associated with a language and communication skills module could be integrated into the broader curriculum of an engineering programme based at a prominent South African university of technology (UOT). The design team consisted of three (3) Language and Communication Skills lecturers, two (2) engineering subject lecturers, two (2) curriculum designers, two (2) industry representatives, and two (2) engineering students. This team engaged with the integration strategy during "design sessions". A focus group interview was held after each session where open ended questions, regarding what worked optimally and what improvements could be made to the strategy, were posed. The design team participated in four (4) focus group interviews, each lasting approximately sixty (60) minutes. A constant comparative analysis was conducted on transcripts of these interviews using Atlas ti Qualitative Data Analysis Software (QDAS). This analysis involved coding the transcripts for emergent themes and patterns in the team's feedback. The themes were then compared across interviews to identify converging and diverging perspectives.to identify themes and patterns in the team's feedback on the effectiveness of the strategy and potential areas for improvement. A refined strategy was then presented to the team during subsequent design sessions, and this cycle of improvement continued until no significant changes were deemed necessary.

B. Literature reflection

A literature reflection was undertaken to ensure that the guiding principles, formulated during the inductive process, were grounded in existing knowledge, identify common themes, patterns, and relationships, and integrate diverse perspectives, enriching and reinforcing the conceptual foundation before constructing the reference model. What follows is a summary outline of these principles.

IV. GUIDING PRINCIPLES

Through a thorough process of coding sorting and analysing, transcripts of all the focus group interviews were distilled into a set of guiding principles regarding how best to integrate language and communication skills into engineering education. These principles were expressed as advisory conjectures and can be summarised as follows:

A. Guiding Principle 1: Cultural Awareness and Leveraging Diversity for Integrated Language and Communication Skills in Engineering Education

If your aim is to integrate the learning outcomes of a language and communication skills module into an engineering curriculum, it is advisable to acknowledge the role of culture in the learning process and leverage the strengths of diversity. By encouraging flexible cultural perspectives, positive engagement, and involvement among learners, you promote a conducive learning environment. This enables content to be situated in relatable and meaningful contexts, fostering the development of a shared culture that facilitates greater learning opportunities (Spoelstra & Collins, 2023).

B. Guiding Principle 2: Adapting Language and Communication Skills Integration in Engineering Education for Diverse Student Abilities and Engagement

If you aim to integrate a language and communication skills module into an engineering program, it is advisable to tailor teaching methods, activities, and learning materials to accommodate a diverse range of student skills and abilities. Assessing students' prior knowledge and language proficiency enables instructors to adapt instructional content appropriately and build upon existing skills. Utilising formative assessments empowers students to identify areas needing improvement and fosters self-directed learning. This flexibility enhances student engagement and enthusiasm toward the module (Spoelstra & Collins, 2023).

C. Guiding Principle 3: Strategic Considerations for Integrating Language and Communication Skills in Engineering Education

When integrating a language and communication skills module, careful consideration should be given structure, learning outcomes, and assessment methods. Language development should be conspicuous in merged modules with engineering subjects, incorporating vocabulary building, technical and non-technical writing, and verbal presentation skills. Guest lecturers can address specialised topics. Practical application can be facilitated through problem-solving activities, collaborative assessment, utilising well-designed rubrics (Spoelstra & Collins, 2023).

D. Guiding Principle 4: Collaborative imperative in the Integration of Language and Communication Skills in Engineering Education

To successfully integrate language and communication skills into engineering education, collaboration among stakeholders is crucial. The academic institution should provide a supportive framework for collaboration across faculties, departments, and with industry partners. Lecturers from different disciplines, including language and communication skills, should engage in feedback sessions to ensure curriculum coherence. Assessments should evaluate both technical and language competencies. Encouraging student agency in decision-making enhances intrinsic motivation and aligns teaching with their interests, fostering enjoyable learning and achievement of outcomes (Spoelstra & Collins, 2023).

E. Guiding Principle 5: Approach learning Holistically when Integrating Language and Communication Skills in Engineering Education

To effectively integrate language and communication skills into engineering education, a holistic approach to learning is advisable, including adult learning, experiential learning, and active learning. Students must understand the value of achieving learning outcomes for their academic and personal goals. Experiential learning engages students in meaningful activities that draw upon their existing knowledge, fostering a sense of accomplishment and reflection. A student-cantered environment, enriched with up-to-date content, promotes critical thinking and relevance (Spoelstra & Collins, 2023).

V. FROM DESIGN PRINCIPLES TO REFERENCE MODEL

Following the inductive phase of the study, a conceptual research approach was employed to craft a reference model for integrating language and communication skills into engineering education. This process entailed a thorough literature review that compared and validated the principles against existing theories, empirical studies, and best practices. Through this iterative process, the principles underwent refinement and enhancement, incorporating new insights and addressing gaps and inconsistencies. The refined principles were then organised and integrated using the norms and guidelines from the CoI framework to create a comprehensive reference model that encompasses the cognitive, social, and instructional facets of educational endeavours. For instance, the emphasis on cultural awareness in Guiding Principle 1 aligns with the CoI's social presence component, fostering a more inclusive learning environment that supports effective communication across diverse backgrounds. This approach facilitated the visual representation of the recommended strategy, encapsulating essential components, principles, and processes in a cohesive and accessible format. This iterative process ensured that the emerging themes (guiding principles) from the focus groups remained grounded in existing knowledge and best practices within engineering education.

The CoI model was deemed particularly suitable as the foundation for the reference model due to its versatile framework that aligns with the interdisciplinary nature of integrating language and communication skills into engineering education. Originally developed for online learning contexts, the CoI framework offers a flexible structure adaptable to various educational initiatives beyond online platforms (Karaoglan-Yilmaz, Ustun, Zhang, K. & Yilmaz, 2023). Conceived by Garrison, Anderson, and Archer (2000), the model comprises three interconnected presences: cognitive presence, social presence, and teaching presence, emphasising their pivotal roles in fostering effective learning experiences (Karaoglan-Yilmaz et al., 2023).

Cognitive presence, centred on continuous communication and reflection, is crucial for knowledge construction and comprehension within a learning community (Garrison, Anderson, & Archer, 2000). Social presence emphasises the cultivation of interpersonal relationships among learners, underlining the significance of communication skills and collaborative community-building (Karaoglan-Yilmaz et al., 2023). Teaching presence encompasses the design and implementation of learning processes to achieve educational objectives, highlighting the instructors' role in guiding and supporting the learning journey (Anderson et al., 2001).

Although the CoI framework originated in the context of online learning (Garrison, Anderson & Archer, 2010), its adaptability to broader educational initiatives is evident. The CoI framework posits that social knowledge construction thrives when attention is given to teaching presence, social presence, and cognitive presence, demonstrating the interconnectedness of these elements and their relevance beyond online learning (Hilliard & Stewart, 2019). This adaptability stems from the model's emphasis on communication dynamics, collaboration, and effective instructional design, which are universally applicable in educational settings.

A conceptual research approach, involving a comprehensive literature review, was undertaken to strengthen the guiding principles developed through the inductive process, forming the conceptual reference model for integrating language and communication skills into engineering education.

A. Literature Reflection

The literature reflection amalgamated insights, shaping the overarching structure of the reference model to better align with the broader educational landscape, thereby enhancing its effectiveness.

1) The Evolving Landscape of Engineering Education: A Focus on Interdisciplinary Competencies

The engineering profession is undergoing a significant transformation, driven by the increasing complexity of real-world challenges and the demands of a globalised workforce. This necessitates a critical reflection on the skillset required by future engineers, prompting educators to move beyond traditional disciplinary approaches and embrace a more comprehensive educational framework. This literature review delves into the evolving landscape of engineering education, with a specific focus on the crucial role of interdisciplinary competencies.

2) Critical Thinking and Problem-Solving for Complex Challenges

Several studies highlight the paramount importance of critical thinking and problem-solving skills in equipping engineers to tackle the intricate issues of the 21st century

(Quelhas et al., 2019; Van den Beemt et al., 2020). These skills empower engineers to analyze problems from diverse perspectives, evaluate information critically, and develop innovative solutions that address the interconnectedness of various factors. Quelhas et al. (2019) emphasise the need for systemic thinking, where engineers consider the "big picture" and the potential ramifications of their decisions, fostering a holistic and sustainable approach to problem-solving.

3) The Power of Effective Communication

The ability to communicate effectively is no longer a peripheral skill in engineering. Studies like Ergai et al. (2022) underscore the critical role of communication skills in fostering successful collaboration and navigating the complexities of a diverse engineering environment. Engineers must be adept at communicating technical concepts clearly and concisely, not only with colleagues from their own discipline but also with individuals from different backgrounds and expertise.

4) Challenges and Opportunities in Interdisciplinary Education

The literature also acknowledges the inherent challenges associated with implementing interdisciplinary education (IEE) (Van den Beemt et al., 2020). These challenges include establishing clear learning objectives, fostering effective collaboration among faculty and students from diverse disciplines, and overcoming institutional barriers that may hinder interdepartmental collaboration. Despite these challenges, the potential benefits of IEE are numerous. Van den Beemt et al. (2020) highlight the ability of IEE to equip students with the skills necessary to tackle complex problems, foster innovation, and prepare them for the collaborative nature of work in a globalised world.

5) Beyond Disciplinary Silos: Embracing Soft Skills

While technical expertise remains crucial, the reviewed literature emphasises the importance of fostering soft skills alongside technical knowledge. Studies like Caeiro-Rodríguez et al. (2021) highlight the significance of cultural awareness and critical thinking in preparing future engineers for the increasingly diverse and interconnected world. These skills enable engineers to navigate cultural nuances effectively, collaborate across cultures, and approach complex problems with an open mind and a critical lens.

6) Pedagogical Approaches: Embracing Project-Based Learning

The literature suggests that project-based learning (PBL) can be a valuable pedagogical tool for developing the competencies discussed above (Caeiro-Rodríguez et al., 2021). PBL fosters a student-centered approach where students work collaboratively on real-world projects, requiring them to apply their knowledge and skills from various disciplines to solve complex problems. This pedagogy promotes critical thinking, problem-solving, communication, and collaboration, all of which are essential for success in an interdisciplinary engineering environment.

7) Future Directions: Assessment and Continuous Development

While significant progress has been made in identifying and fostering essential competencies in engineering education, further research is needed to address the challenges associated with assessment and continuous curriculum development. Studies like Van den Beemt et al. (2020) and Caeiro-Rodríguez et al. (2021) highlight the need for effective assessment methods to evaluate the development of transversal competencies, such as critical thinking and communication, within an interdisciplinary framework. Additionally, the continuous evolution of the engineering landscape necessitates ongoing research and development of educational strategies to ensure engineering graduates remain equipped with the necessary skillset to thrive in the dynamic world they face.

The reviewed literature presents a compelling case for the integration of interdisciplinary competencies into the curriculum of engineering education. By fostering critical thinking, problem-solving, effective communication, and collaboration, alongside essential technical skills, engineering education can equip future generations with the tools they need to address the complex challenges and opportunities of the 21st century. As engineering education continues to evolve, embracing a holistic approach that transcends traditional disciplinary boundaries will be critical in preparing engineers for a successful and impactful future.

B. Aligning Guiding Principles and Literature to Inform the Creation of the CoI Framework

Both the guiding principles and the literature review findings, informed the development of the reference model, which integrates Language and Communication Skills (LCS) into Engineering Education.

The guiding principles, derived from the focus group interviews, emphasised the importance of cultural awareness, diverse student abilities, strategic integration methods, collaboration among stakeholders, and a holistic learning approach (Guiding Principles 1-5). These principles resonated strongly with the findings from the literature review.

The literature review underscored the critical role of cognitive presence, highlighting the need for engineers to tackle complex challenges through critical thinking, problem-solving, and effective communication (Quelhas et al., 2019; Van den Beemt et al., 2020). This directly aligns with Guiding Principle 1, which emphasises cultural awareness and leveraging diversity to foster a learning environment that promotes critical thinking and communication skills.

Furthermore, the literature review emphasised the importance of social presence, pointing to the benefits of project-based learning (PBL) in fostering collaboration and communication skills within a culturally diverse environment (Caeiro-Rodríguez et al., 2021). This aligns with Guiding Principles 2 and 4, which advocate for adapting instruction to diverse abilities and fostering collaboration among stakeholders for successful LCS integration.

Finally, the literature review highlighted the role of teaching presence, emphasising the importance of instructional design and effective assessment strategies that encompass both technical and communication skills (Van den Beemt et al., 2020; Caeiro-Rodríguez et al., 2021). This aligns with Guiding Principle 3, which emphasizes strategic considerations for integrating LCS, including well-designed assessments and practical application through activities like problem-solving.

By integrating the insights from both the guiding principles and the literature review, the reference model draws on the CoI framework. The model emphasises all three CoI components: Cognitive Presence for critical thinking and communication, Social Presence for fostering a collaborative and culturally aware learning environment, and Teaching Presence for effective instructional design and assessment strategies. This comprehensive approach ensures the successful integration of LCS into engineering education, equipping students with the necessary communication skills to thrive in a globalised and technologically advanced world.

The CoI framework, as detailed in Table 1, outlines specific strategies for cultivating social, cognitive, and teaching presence within the learning environment. The information presented in the table synthesises both the guiding principles developed through inductive research and the insights gained from the subsequent conceptual research phase.

Table I: CoI Framework: Integrating Language & Communication Skills into Engineering Education

TABLE I
COMMUNITY OF INQUIRY (COI) FRAMEWORK: INTEGRATING LANGUAGE & COMMUNICATION SKILLS INTO ENGINEERING EDUCATION

Social Presence	• **Build interdisciplinary teams:** Foster a sense of community and enrich discussions and collaborations by forming teams consisting of students from different disciplines, promoting cross-cultural learning and collaboration (Caeiro-Rodríguez et al., 2021). • **Facilitate cross-disciplinary interactions:** Organise workshops, seminars, and guest lectures involving experts from various fields to create a sense of shared learning and community across disciplines, fostering cultural awareness and understanding of diverse perspectives (Van den Beemt et al., 2020). • **Utilise technology for collaboration:** Leverage online platforms and collaborative tools to facilitate communication and interaction between students and faculty from different disciplines, fostering a sense of connectedness despite geographical limitations. • **Promote positive engagement through cultural awareness:** Create inclusive learning environments and encourage active participation by assessing prior knowledge, language proficiency, and cultural backgrounds. This fosters positive engagement and respectful interactions within the learning community (Caeiro-Rodríguez et al., 2021). • **Embrace a student-centered environment:** Utilise experiential and active learning activities to encourage meaningful interactions and discussions within a student-centered environment, fostering critical thinking, problem-solving, and collaboration skills (Caeiro-Rodríguez et al., 2021).
Cognitive Presence	• **Promote Flexible Cultural Perspectives:** Encourage critical thinking and understanding within a diverse learning community by acknowledging cultural influences and fostering intercultural communication skills (Caeiro-Rodríguez et al., 2021). • **Tailor Teaching and Content for Diverse Student Abilities:** Adapt instruction to accommodate different learning styles and cultural backgrounds, fostering critical thinking and problem-solving skills across diverse student populations (Quelhas et al., 2019). • **Integrate Language Development:** Support critical thinking and problem-solving by incorporating effective communication and language development into engineering modules, emphasising clear and concise communication across disciplines (Ergai et al., 2022). • **Collaborate with Stakeholders:** Enhance critical thinking and knowledge construction through collaboration with various stakeholders, including industry professionals, to introduce real-world, complex problems requiring interdisciplinary knowledge (Van den Beemt et al., 2020). • **Promote Holistic and Interdisciplinary Learning:** Encourage deeper understanding and engagement by employing a holistic approach that integrates concepts and methodologies from multiple disciplines, fostering systemic thinking (Van den Beemt et al., 2020).
Teaching Presence	• **Develop Interdisciplinary Learning Modules:** Design courses and modules that integrate concepts and methodologies from multiple disciplines, fostering a holistic understanding of complex problems and interdisciplinary thinking (Van den Beemt et al., 2020). • **Facilitate Interdisciplinary Collaboration:** Provide guidance and support to students as they navigate the complexities of interdisciplinary learning and communication, promoting cross-disciplinary teamwork and collaboration (Caeiro-Rodríguez et al., 2021). • **Design Activities Addressing Diversity:** Enhance both cognitive and social presence by designing activities and discussions that explicitly address cultural diversity and encourage intercultural communication skills. • **Formative Assessments and Adaptable Teaching:** Implement formative assessments and adaptable teaching strategies to empower students to engage at their own level, fostering cognitive and social presence for all learners (Caeiro-Rodríguez et al., 2021). • **Assessment of Interdisciplinary Competencies:** Develop assessment strategies that evaluate not only disciplinary knowledge but also the ability to integrate knowledge from different disciplines, communicate effectively across diverse audiences and collaborate effectively in interdisciplinary teams (Van den Beemt et al., 2020). • **Collaboration and Feedback Sessions:** Promote coherence in the curriculum and benefit both cognitive and social presence through regular collaboration and feedback sessions among instructors. This encourages shared best practices and continuous improvement in interdisciplinary learning (Van den Beemt et al., 2020). • **Holistic Approach by Instructors:** Create dynamic and engaging learning environments by adopting a holistic approach that aligns with cognitive, social, and interdisciplinary learning goals. This fosters a

vibrant and inclusive learning community (Caeiro-Rodríguez et al., 2021).

Fig.1. depicts the intricate interplay and connections among the social, cognitive, and teaching presences within the CoI reference model, offering a visual representation of their relationships and interactions.

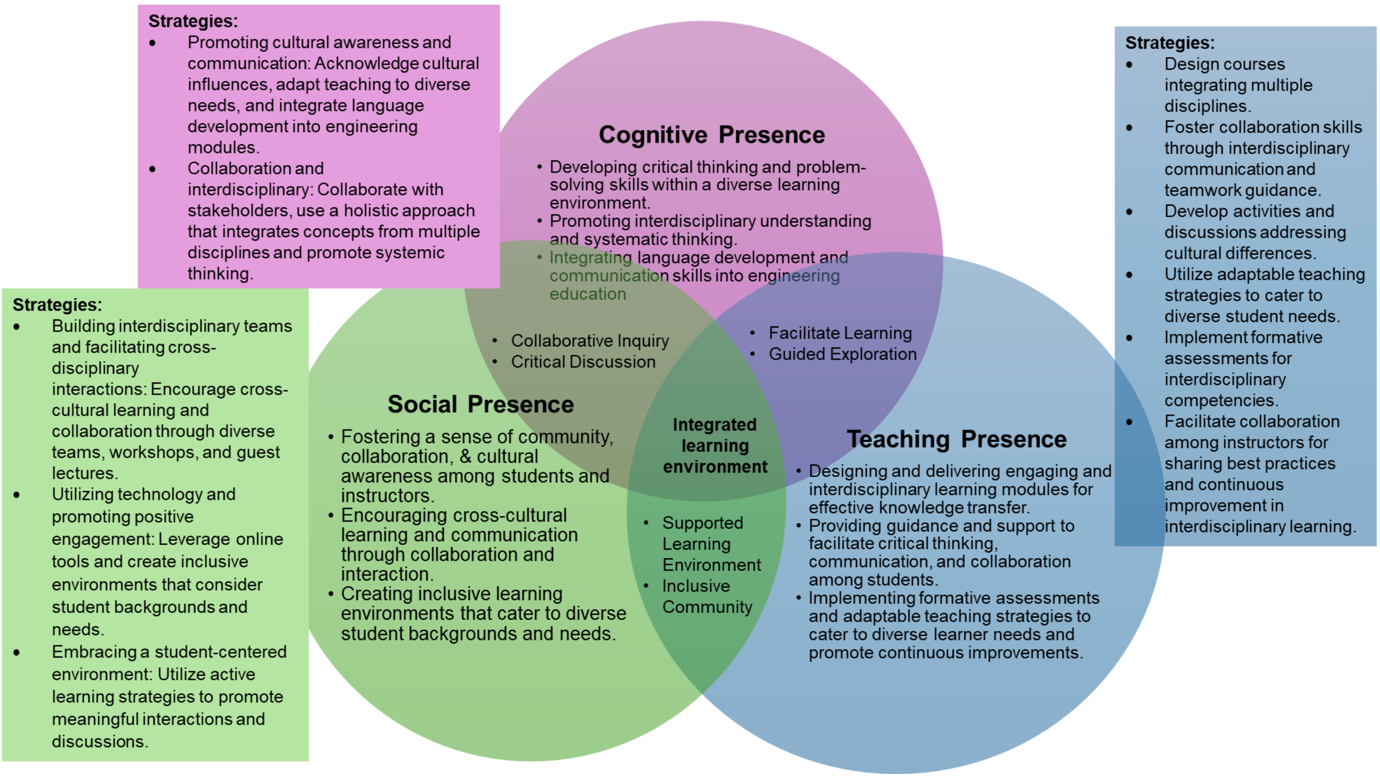

Fig. 1. Integrated CoI Framework

This integrated CoI framework provides a comprehensive and practical approach to fostering interdisciplinary competencies within engineering education. It emphasises the importance of **critical thinking, communication, collaboration, and cultural awareness** while acknowledging the need for **diversity and inclusion** in the learning environment.

C Practical Application and Recommendations for Educators

To illustrate the framework's application, consider, for example, a project-based learning (PBL) scenario where a civil engineering class tackles bridge design. Students from diverse cultural backgrounds could form interdisciplinary teams, collaborating with a guest lecturer on urban planning to incorporate social and environmental considerations. This project would encourage students to not only employ technical vocabulary effectively but also present their findings to a mixed audience, fostering clear and concise communication across disciplines and backgrounds. This exemplifies how the CoI framework, through its emphasis on social and cognitive presence, can be integrated with PBL activities to cultivate essential communication skills within an engineering context. Figure 2 illustrates how this PBL scenario can be analysed through the CoI framework lens, fostering social presence, cognitive presence, and teaching presence within the engineering education environment.

Building on this example, the following recommendations detail specific steps educators can take to implement the CoI framework and effectively integrate communication skill development within their engineering courses.

- **Contextualise the Framework:** Identify the specific communication skills most relevant to

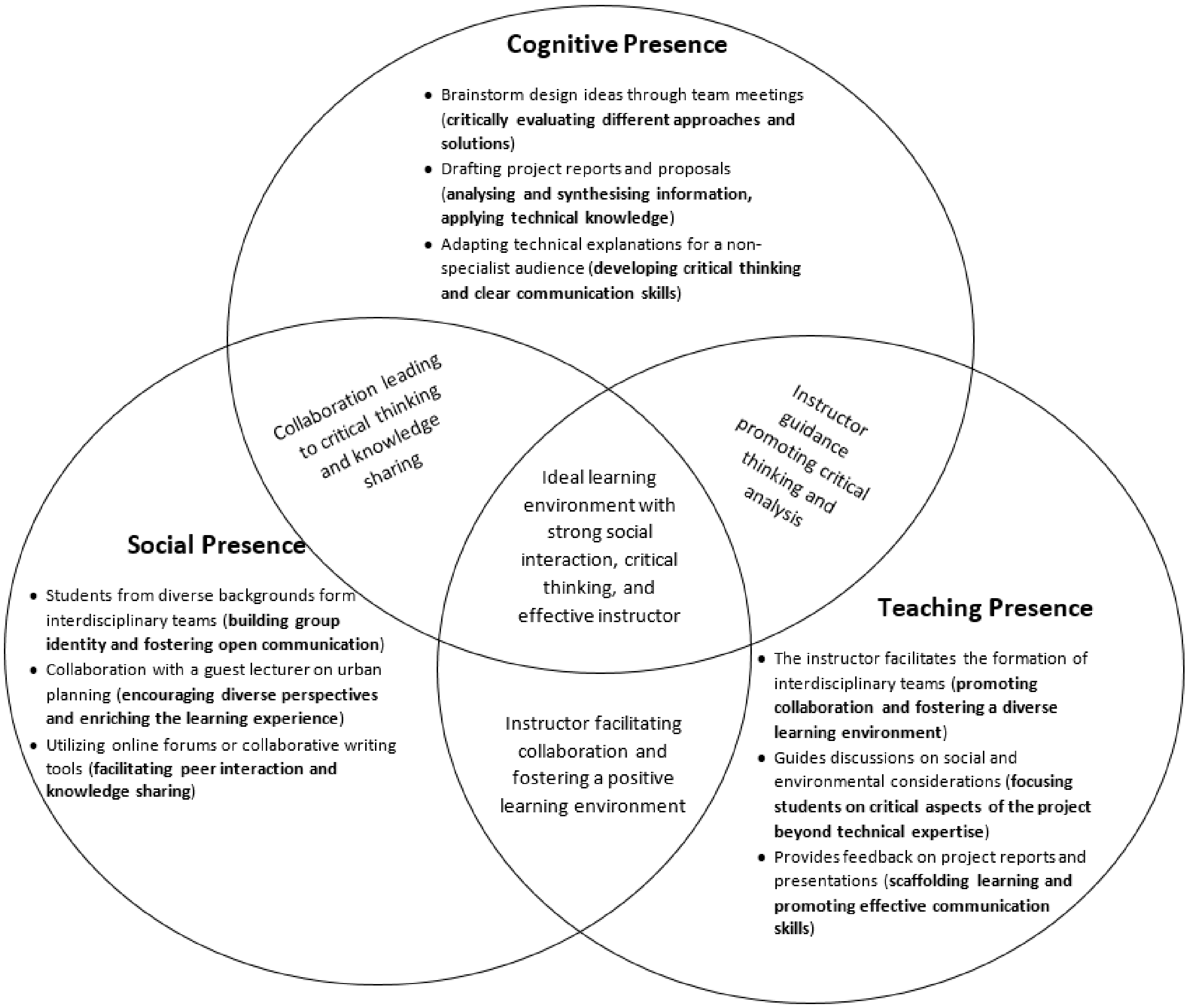

Fig. 2. A Project-based learning (PBL) scenario viewed through a CoI lens

the engineering discipline and course learning objectives. Align the CoI activities within the framework to address these targeted skills.

- **Foster Collaboration:** Create opportunities for teamwork and peer interaction throughout the course. Utilize online forums or collaborative writing tools to encourage students to share ideas and provide constructive feedback.
- **Assessment and Reflection:** Integrate communication skills into assessment rubrics for projects, presentations, and reports. Encourage students to reflect on their communication strengths and areas for improvement throughout the course.

By incorporating these steps, educators can leverage the framework to create a structured and effective learning environment that fosters the development of vital communication skills alongside technical expertise.

DISCUSSION AND CONCLUSION

This study has addressed the ongoing challenge of integrating language and communication skills (LCS) within the traditionally technical curriculum of engineering education. While technical expertise remains fundamental, the modern engineering landscape increasingly demands individuals with strong social responsibility, global engagement, and effective communication. However, engineering students often fail to recognise the relevance of LCS, perceiving them as an additional burden in an already demanding programme.

This study emphasises the importance of contextualising LCS within engineering education and proposes a comprehensive framework for their integration. This framework draws upon inductively formulated guiding principles that highlight the importance of interdisciplinary collaboration, knowledge sharing, and resource sharing. This integrated approach not only enhances the perceived value of LCS but also equips future engineers with a broader skillset for success in a globalised and interconnected world.

The study employed a rigorous research approach, combining an inductive phase with a conceptual research approach. This involved an extensive literature reflection comparing and validating the guiding principles against existing theories and best practices in LCS integration. The resulting reference model, viewed in conjunction with the guiding principles, captures essential components, principles, and processes in a cohesive and accessible manner, serving as a practical roadmap for educators and curriculum designers.

Furthermore, the study incorporates the CoI framework as a foundation for the reference model, strengthening its relevance to collaborative, interdisciplinary learning environments. The CoI framework's focus on cognitive presence, social presence, and teaching presence, aligns well with the potential benefits of integrating LCS.

To enhance cognitive presence, the proposed framework advocates for integrating activities centred around engineering communication, such as technical report writing, oral presentations, and problem-solving discussions focused on real-world challenges. Additionally, it encourages students to move beyond simply expressing ideas by promoting the use of language for critical analysis and information synthesis. Recognising the challenges faced by students from diverse language backgrounds, the framework suggests providing supplementary resources, differentiated assignments, and peer-to-peer learning opportunities to ensure the successful development of these crucial skills.

To foster social presence, the framework emphasises the creation of inclusive learning environments that celebrate cultural diversity and empower students to confidently use and develop their language skills. This fosters respectful interactions and cross-cultural understanding. The framework further promotes collaborative projects and activities encouraging students to communicate effectively with diverse peers within and across disciplines. Finally, it advocates for leveraging online platforms and collaborative tools to facilitate communication and active participation regardless of location.

Facilitating teaching presence, the framework emphasises the design of activities and discussions that directly target the development of engineering-specific language and communication skills. This includes providing regular and constructive feedback on language use, focusing on clarity, conciseness, and technical accuracy alongside content itself. Additionally, the framework encourages instructors to model and promote effective communication practices within the classroom setting, fostering a culture that welcomes questioning, clarification, and respectful debate, ultimately contributing to students' mastery of these skills.

By incorporating these CoI-informed elements, the proposed framework can guide the development of a dynamic learning environment that empowers engineering students to develop the essential LCS necessary for success in the 21st century. By fostering critical thinking, inclusivity, and collaboration through language, this framework equips future engineers to navigate the complexities of their profession and contribute effectively to a globalised and interconnected world.

In conclusion, this study offers a valuable contribution by proposing a comprehensive framework and utilising the CoI framework to integrate LCS into broader engineering education. This approach has the potential to equip future engineers with the broader skillset required to thrive in the demanding and evolving landscape of the engineering profession.

Limitations

While this study offers a valuable framework, it needs to be acknowledged that focus group participants were drawn from experts in the South African context, though this was mitigated, to some extent, by a wider literature reflection, the findings may not be directly generalisable to all engineering institutions in other cultural, social, and economic environments. The study's reliance on qualitative data, and its lack of long-term outcome assessment, are, in addition, acknowledged as limitations. Further research could explore the framework's generalisability, incorporate quantitative data, investigate long-term impacts, and delve deeper into implementation challenges and power dynamics within the learning environment.

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