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Heart and Mind of Engineering Educator: The Emotional Dimensions of Facilitating Student-Centered Learning

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ABSTRACT

BACKGROUND & CONTEXT

Higher educational institutions increasingly adopt student-centered learning (SCL) approaches to cultivate content knowledge mastery and professional skills among engineering students. Effective facilitation is critical in ensuring the success of SCL. Implementation and facilitation of SCL approaches can exert significant emotional impacts on both instructors and students. While students' emotional experiences have been extensively investigated, instructors' emotional journeys during facilitation, encompassing both challenges and successes, remain substantially understudied.

PURPOSE OR GOAL

This conceptual paper examines the challenges in facilitation experiences of engineering educators and analyzes their emotions throughout this process. Additionally, this paper investigates the multilevel implications of these emotions.

APPROACH OR METHODOLOGY

This paper systematically synthesizes existing literature from peer-reviewed engineering education papers across three domains: (a) facilitation challenges in engineering education, (b) instructors' emotional experiences when implementing SCL approaches, and (c) the multilevel implications of instructors' emotional responses.

OUTCOMES

The analysis reveals a diverse range of challenges during facilitation processes, and they experienced complex combinations of both positive and negative emotions when facilitating student learning. These emotional responses have significant implications on instructors' motivation and persistence in designing and sustaining SCL practices, with potential cascading effects on student outcomes and institutional performance.

CONCLUSIONS

While evidence indicates a paradigm shift toward SCL approaches in engineering education, a critical need exists to expand our understanding of instructors' emotional experiences during facilitation. Developing this knowledge base is essential for creating effective support mechanisms for engineering educators implementing innovative pedagogical approaches.

KEYWORDS

Emotions, Facilitation, Student-centred learning (SCL), Engineering Educators.

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Introduction

In engineering education, educators are increasingly encouraged to adopt student-centered learning (SCL) approaches to address contemporary educational needs and future workplace demands. Research indicates that SCL enhances engineering students' learning, including engagement and motivation (Wijnia et al., 2024). These improvements ultimately contribute to deeper conceptual understanding (Yadav et al., 2014) and the development of transferable skills (Chidthachack et al., 2021). However, implementing SCL approaches presents considerable challenges. While students are supposed to take responsibility of their learning, it does not mean that students are left on their own when a SCL approach is adopted. A well-designed curriculum coupled with effective instructor facilitation is essential to ensure successful implementation of these pedagogical methods. Facilitation is defined as the art of guiding students to take an active role in their own learning through collaborative and experiential processes (Knowles, 1980). In this process, educators help students foster self-directed learning and critical thinking by providing scaffolding through various instructional strategies, including posing thought-provoking questions, encouraging meaningful dialogue, and modeling analytical reasoning (Hmelo-Silver, 2004). As students progressively develop competence and autonomy, the extent of instructional support gradually decreases, enabling learners to transition toward greater independence in their learning (Hmelo-Silver, 2004).

As engineering educators engaged in pedagogical shifts to SCL, they experience significant changes in their role, from the 'sage on the stage' to 'guide on the side' who facilitates students learning. These changes are not limited to pedagogical practice but also involves the significant shifts in their beliefs and identities as engineering educators which brings significant emotional implications. However, engineering is traditionally viewed as a rational discipline; emotions are sidelined and often neglected (Lönngren et al., 2024). In recent years, the role of emotions in teaching and learning gained momentum in research. Pekrun (2014) emphasized that the classroom is an emotional place where emotions play important role in students' attention, motivation, choice of learning strategies and engagement in self-regulated learning. However, limited studies had focused on engineering educators' emotions in teaching and learning. Engineering educators experience significant changes in the 21st century. First, they are expected to embrace the role as teacher despite they have received limited, or no training related to teaching and learning before they begin their teaching career (Brownell & Tanner, 2017). Second, as recommended by the accreditation body and institutions, they also experiencing transformation in their pedagogical practice, shifting from teacher-centered to SCL. As noted by Trigwell (2011), teacher emotion in higher education remains an under-research area that need to be addressed due to its significance in teachers' cognition and motivation, which can cascade to students' perception and learning. Thus, this conceptual paper addresses the research gap by focusing on engineering educators, which represents hard disciplines where emotions are often sidelined when they transitioned to facilitating engineering students' learning.

Literature Review

Student-centered Learning in Engineering Education

In higher educational institutions, educators strive to optimize students' learning experience and aim to produce graduates who are workplace ready. It is criticized that teacher-centered approach are no longer sufficient to address the current educational needs and labor market expectation (Thi Quynh Lan, 2018). Teachers' pedagogical decisions affect students' learning experiences directly. As early as in the mid-1990s, ABET began emphasizing a student-centered approach by encouraging program to adopt evidenced-based practice such as active learning, project-based learning, problem-based learning that proven to enhance engineering students' application of learning, problem-solving, critical thinking and teamwork skills (Lattuca et al., 2006). However, teacher-centered strategies are prevalent throughout undergraduate STEM curriculum, where students primarily listened to instructors during their classes (Stains

et al., 2018). Even there are increasing evidence showing the effectiveness of SCL approaches, the adoption rate of these approaches in engineering program remains a concern. While many engineering educators express interest in implementing SCL approaches, research indicates they face numerous challenges that threaten the sustainability of these efforts. Previous studies examining SCL in higher education have documented a variety of implementation barriers, these challenges include managing large class sizes, working within time constraints, navigating content-heavy curricula, aligning with existing teaching and assessment policies, addressing facility limitations, managing increased faculty workload and overcoming insufficient pedagogical knowledge and skills required for effective implementation (Seng, 2014; Katawazai, 2021). This study focuses specifically on the pedagogical knowledge and skills challenge among engineering educators, with particular emphasis on facilitation capabilities which represents a foundational skill set that directly impacts teaching and learning effectiveness. Unlike structural challenges that may require extensive administrative intervention, enhanced pedagogical knowledge and facilitation skills empower educators to implement SCL more effectively regardless of institutional context. While addressing other challenges remains important, strong facilitation skills provide educators with essential tools to adapt and implement SCL across various educational environments.

Facilitation in Engineering Education

Facilitation is central in SCL, it stems from the humanistic perspective that emphasizes students' need for development. Through facilitation, students become more adaptable and self-directed in their learning (Rogers, 1983). Burrows (1997) defined facilitation as "…a goal orientated dynamic process, in which participants work together in an atmosphere of genuine mutual respect, in order to learn through critical reflection." based on a comprehensive concept analysis. From a constructivist perspective, facilitation refers to creating an enabling atmosphere that allows students to construct their own understanding through interactions with the environment and experiences (Gautam & Agarwal, 2024). In this approach, teachers play the role of facilitator to guide students through the inquiry process, helping them explore, investigate, solve the problems and present the findings.

Effective facilitation is a dynamic process where both learners and teachers actively co-construct the learning experiences. Facilitation requires voluntary engagement from both learners and teachers who collaborate to achieve the learning goals. This partnership differs from conventional knowledge transmission paradigm, both teachers and students should share a clear understanding of their respective role and responsibilities (Burrows, 1997). The teacher acknowledges that their purpose is not to disseminate the knowledge but to create engaging environments that activate students to learn. Similarly, students understand that they are active agents in constructing their own understanding. Effective facilitation requires teachers to possess good pedagogical content knowledge alongside interpersonal skills and self-awareness to empower students in learning. Transitioning from traditional teaching to a facilitative role poses significant challenges for many educators. Adopting SCL often generates uncertainty, as teachers struggle to determine the appropriate level of support and facilitation needed to foster student autonomy (Starrett, Firetto, & Jordan, 2022).

The challenges encountered by teachers in pedagogical shifts often triggered a variety of emotions. In teacher education, research had called upon attention on teachers' emotions due to its significance in educational decisions, work satisfaction and retention as well as psychological well-being. Teacher emotions refer to socially constructed, and personally enacted ways of being that emerge from conscious and/or unconscious judgements regarding perceived successes at attaining goals or maintaining standards or beliefs during transactions as part of social-historical contexts (Schutz et al., 2006). This definition indicates that teacher emotions represent teachers' own evaluations of how well they are achieving their professional goals which are embedded within the social norms, cultural expectations, and professional standards of the educational context. Furthermore, these emotions are shaped by teachers' personal histories, beliefs, and dispositions, highlighting the interplay between individual

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agency and broader social structures in the formation of professional emotional experiences. Frenzel et al. (2021) explained that teacher emotions can affect student outcomes, including emotions, beliefs, motivation, discipline, and performance through direct and recursive pathways. The conceptual framework suggests that the impact of teacher emotions on student outcomes is mediated by teaching behavior, which underlines how teacher emotions could affect instructional strategies and interactions with students, ultimately influencing student outcomes (Frenzel et al., 2021).

Most engineering educators transition from engineering careers to academia with strong technical skills but limited pedagogical knowledge (Brownell & Tanner, 2012). However, ABET accreditation requirements necessitate student-centered pedagogies such as active learning and problem-based learning (ABET, 2023). These approaches require educators to shift from content delivery to facilitation, a transition that often generates significant stress and negative emotions. Research documents how these challenges impact teaching effectiveness, yet a systematic understanding of educators' emotional experiences during facilitation remains limited. This paper addresses this gap by systematically reviewing the literature on engineering educators' emotional experiences during facilitation.

Methodology

The study explores the complex interplay between educators' emotions and their facilitation approaches in SCL environments, investigating how these emotional dimensions create recursive relationships that impact engineering educators themselves, their students, and their institutions. The following research questions were formulated:

a) What challenges do instructors encounter when facilitating students learning in engineering education?
b) What are instructors' emotional experiences when facilitating students' learning?
c) What are the implications of these emotional experiences on engineering educators, their students, and their institutions?

The articles included in this paper is a subset focusing on engineering educators from a systematic literature review which focuses on instructors' emotions when transitioning to SCL at higher education. The literature search was guided by key terms, including "teacher," "student-centered learning," and "emotions" as well as the equivalent terms. Multiple databases were searched, key publications addressing the research focus were identified. Thematic analysis was used to identifying recurring themes related to facilitation strategies, emotional experiences, and multilevel impacts. Findings were then synthesized inductively to develop an integrated understanding of relationships between emotions, facilitation practices, and outcomes at various levels.

Results and Analysis

This section of the paper presents the key findings emerged from 9 qualitative research focuses on the engineering educators' experiences when facilitating students' learning in SCL.

Challenges of Facilitating in Engineering Education

Seven primary themes emerged regarding facilitation challenges as shown in Table 1. The first theme concerned curriculum, activity design, and implementation challenges. Engineering educators reported specific challenges, including framing appropriate learning outcomes, integrating student-centered strategies into courses, setting and scoping problems, balancing content coverage, and establishing external partnerships. These pre-implementation preparations are critical as they establish the foundation for effective facilitation. Content coverage represents one of the most significant concerns, as one educator noted: "biggest challenge in this re-design was deciding how to condense content to make time for collaborative activities" (Ralston, 2017). Although frequently overlooked, establishing external partnerships is essential as these relationships provide sources for authentic problems and

access to information students need to solve these problems. As Du et al. (2021) illustrates: "She designed a real-life problem as a theme…But since she did not have an advance agreement with the companies, students experienced difficulties accessing those systems."

Table 1: Themes and Subthemes for Challenges of Facilitating in Engineering Education

Theme	Subthemes
Curriculum, Activity Design and Implementation Challenges	1. Planning and design of learning experiences 2. Facilitating student learning and engagement 3. Resource and support needs
Instructor Knowledge, Skills and Readiness	1. Pedagogical knowledge and skills 2. Subject matter mastery 3. Readiness in facilitation
Instructor Beliefs and Identity	1. Beliefs about teaching and learning 2. Beliefs and perceptions about students 3. Beliefs about instructor role and identity 4. Personal background and characteristics
Workload and Time Management Challenges	1. Challenges in managing time 2. Task-related workload 3. Challenges related to new courses
Students Challenges and Characteristics	1. Challenges with student attitudes and willingness 2. Challenges with student preparedness, skills and understanding 3. Challenges with student learning preferences and behaviors 4. Challenges in student collaboration and teamwork 5. Challenges related on student background and diversity
Institutional, Departmental, & Cultural Challenges	1. Departmental and institutional challenges 2. Collegial and cultural environment 3. Structural and logistic constraints

During course implementation, engineering educators encountered significant challenges related to workload and time management (Theme 4). During facilitation, they observed that activities frequently required more time than anticipated. Educators also noted that allocated class time was often insufficient when transitioning from traditional teaching methods to facilitating student learning (Du et al., 2021). Additionally, they reported increased workloads associated with planning, activity coordination, providing feedback, and assessment (Chance et al., 2020; Radzali et al., 2018; Ralston et al., 2017; Sengul, 2022; Tucker et al., 2013). The workload and time commitment challenges were often exacerbated when educators were assigned new courses, requiring additional time and effort to prepare and familiarize themselves with course content and structure (Evenhouse et al., 2017; Radzali et al., 2018).

Instructor knowledge, skills, and readiness emerged as a significant theme among facilitation challenges. Engineering educators reported deficiencies in pedagogical knowledge, which manifested in difficulties interacting with students, using questions to facilitate student thinking, and providing effective feedback (Radzali et al., 2018; Sengul, 2022). These challenges may be attributed to a lack of formal pedagogical training among engineering faculty (Sengul, 2022). Additionally, instructors identified concerns regarding subject matter mastery (Radzali et al., 2018; Sengul, 2022). These skill deficiencies may contribute to reduced readiness and confidence among instructors attempting to facilitate student learning in student-centered environments (Mitchell & Rogers, 2020).

Another significant challenge in facilitating SCL stems from engineering instructors' beliefs and professional identity (Theme 3). When transitioning to facilitative roles, instructors with teacher-centered beliefs and positivist views may experience diminished effectiveness (Radzali et al., 2018; Ralston et al., 2017). These educators often favor traditional lectures over transferring control to students for self-directed learning. Additionally, when instructors experience uncertainty about their roles as engineering educators, they may question their professional priorities. Engineering educators often demonstrate reluctance to allow students to lead their learning, particularly when they hold stereotypical views of engineering students as individuals

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who avoid social interaction (Chance et al., 2020). Furthermore, instructors may underestimate their students' capabilities, perceiving them as unable to learn effectively when required to assume control of their learning (Radzali et al., 2018; Sengul, 2022; Tucker et al., 2013).These beliefs often originate from instructors' backgrounds and characteristics, including their past learning experiences and negative encounters with collaborative work (Chance et al., 2020; Mitchell & Rogers, 2020; Radzali et al., 2018).

Engineering educators identified several student-related challenges when implementing facilitative approaches (Theme 5). Students often resisted SCL due to unpreparedness, limited appreciation of the approach, and preferences for traditional lectures (Du et al., 2021; Moore et al., 2015; Radzali et al., 2018; Sengul, 2022; Tucker et al., 2013). Insufficient readiness for collaborative learning created group dynamics issues requiring intervention. Student diversity in academic backgrounds and language barriers added further complexity (Sengul, 2022; Ralston et al., 2017). Notably, some educators anticipated student resistance (Evenhouse et al., 2017; Radzali et al., 2018; Sengul, 2022), which may have influenced their implementation approach and created a self-fulfilling prophecy that exacerbated these challenges.

Beyond individual and classroom-level challenges, engineering educators identified broader socio-environmental obstacles involving colleagues, administrators, and institutional policies (Theme 6). Teacher-centered culture, as a prevailing departmental norm, manifested as collegial resistance and skepticism when educators transitioned to facilitative teaching roles (Du et al., 2021; Radzali et al., 2018; Tucker et al., 2013). Departmental priorities emphasizing research and industrial projects further discouraged investment in pedagogical experimentation and enhancement (Tucker et al., 2013). They encountered administrative barriers when attempting to implement pedagogical changes, navigated conflicting policies between institutional mandates and departmental expectations, and worried that negative student evaluations resulting from unfamiliar teaching methods could harm their tenure prospects (Du et al., 2021; Moore, 2015). Structural issues such as large class sizes (Du et al., 2021; Ralston et al., 2017), physical classroom constraints (Du et al., 2021), and insufficient allocated class time (Du et al., 2021; Evenhouse et al., 2017) created additional barriers to successful implementation of SCL.

Emotional Landscape of Engineering Educators

Engineering educators experienced diverse emotional responses when transitioning to facilitative roles. The research identified four primary themes characterizing these emotional experiences: anticipatory emotions, emotional toll of facilitation, relational emotions, professional identity emotions, and achievement and growth emotions (Table 2).

Table 2: Themes and Subthemes for Engineering Educators' Emotional Experiences

Themes	Subthemes
Anticipatory Emotions	1. Exploratory interest (Epistemic emotions)
	2. Cautious uncertainty about implementation
	3. Optimism for pedagogical change
Emotional Toll of Facilitation	1. Emotional overwhelm
	2. Emotional experiences related to control
	3. Emotional experiences related to unmet expectations
Relational Emotions	1. Emotional attunement with students
	2. Emotional experiences of collegial isolation
	3. Emotional experiences with supportive professional community
Achievement and Growth Emotions	1. Emotional experiences related to 'surviving' the challenge
	2. Emotions related to student growth
	3. Emotions of personal development

Prior to implementation, engineering instructors exhibited complex anticipatory emotions (Theme 1). Some instructors expressed epistemic emotions, demonstrating exploratory interest, curiosity, and intrigue toward SCL and their evolving roles (Chance et al., 2020; Du et al., 2021; Tucker et al., 2013; Ralston et al., 2017). Participants expressed optimistic emotions,

including hope and enthusiasm, when experimenting with new pedagogical methods that offered potential for enhanced student learning experiences (Du, 2021; Radzali, 2018). However, uncertainties regarding SCL and its effectiveness generated hesitancy among instructors considering new approaches (Chance, 2020; Ralston, 2017).

Emotional toll of facilitation was among the most prominent emotional experiences during engineering educators' pedagogical transitions (Theme 2). They described being overwhelmed by intense emotions, including anxiety, fear, and exhaustion (Chance, 2020; Du, 2021; Mitchell, 2020; Ralston, 2017). The transition to facilitative roles often resulted in diminished feelings of control, with instructors reporting discomfort and a sense that their new roles felt "unnatural" (Chance, 2020; Evenhouse, 2017). Concurrently, educators experienced emotions of powerlessness and constraint when confronting seemingly insurmountable institutional challenges (Du, 2021; Moore, 2015). Furthermore, instructors frequently entered the transformation process with specific expectations regarding outcomes and experiences. When these expectations remained unmet, educators commonly reported frustration, diminished enthusiasm, and dissatisfaction with the results of their pedagogical changes (Chance, 2020; Du et al., 2021; Radzali et al., 2018).

Emotional experiences during pedagogical transformation frequently emerged from interactions within the social environment, focusing on interactions with students and colleagues (Theme 3). When facilitating student learning, engineering educators valued emotional attunement with their students, encompassing both emotional distance and synchronicity. Instructors who encountered student resistance reported feelings of isolation and disconnection (Evenhouse et al., 2017), whereas those with positive facilitation experiences used terms such as "closer" and "connected" to describe their satisfactory relationships with students (Sengul, 2022). Another critical dimension of relational emotions concerned interactions with colleagues. The absence of collegial support was associated with negative emotions, including frustration and feelings of isolation (Du et al., 2021). To avoid negative emotions, a participant retreated to familiar pedagogical approaches (Radzali et al., 2018). Conversely, supportive collegial environments and professional communities were consistently associated with positive emotional experiences, including happiness, joy, and a sense of collegiality (Chance et al., 2020; Sengul et al., 2022).

Theme 4 encompasses engineering instructors' emotional experiences related to achievement and professional growth. Following implementation of new pedagogical approaches, engineering educators reported feelings of relief at having successfully navigated the associated challenges (Evenhouse et al., 2017). The initial uncertainties and apprehensions were ultimately disconfirmed through successful practice. When engineering educators reflected on their students' academic progress and learning gains, they expressed a diverse array of emotions. Many instructors reported being surprised and moved by their students' enhanced performance (Du et al., 2021; Moore et al., 2015; Ralston et al., 2017). Additionally, educators expressed appreciation for the pedagogical benefits they observed, recognizing the effectiveness of SCL in promoting learning outcomes (Du et al., 2021; Mitchell et al., 2020). Instructors also described significant emotional experiences related to their own professional development. Through sustained practice, they developed greater mastery over their pedagogical approaches and experienced increased confidence and empowerment in their teaching roles (Chance et al., 2020; Du et al., 2021; Sengul, 2022).

Multilevel Implications of Instructors' Emotions

This investigation systematically categorizes the implications of instructors' emotional experiences across four distinct levels: instructor, classroom, institutional, and broader academic community (Table 3). While the study does not establish causal relationships between emotions and outcomes, it explores how emotional experiences appear to influence the decision-making processes and illustrates the interconnected nature of these experiences on educational practice, professional development, and institutional change.

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Table 3: Multilevel Implications of Instructors' Emotions

Theme	Subthemes
Instructor's Personal Development	1. Shift of instructor's belief and mindset 2. Professional identity development 3. Pedagogical knowledge and skills development
Instructor's Pedagogical Adjustment	1. Shift to student-centered learning 2. Balancing innovation and traditional methods 3. Reverting to traditional methods
Student Development Outcomes	1. Fostering student agency and responsibility 2. Developed skills for real-world application 3. Increased motivation to learn and engagement 4. Enhanced understanding and learning
Curriculum and Programmatic Changes	1. Curriculum development 2. Scaling and program-level implementation
Contribution to research community	1. Advancing scholarly knowledge 2. Fostering collaborative academic communities

At the instructor level, engineering educators experience significant personal and professional development through substantial transformations in their educational beliefs and pedagogical orientations. Research demonstrates a notable shift from teacher-centered to student-centered instructional paradigms, with faculty increasingly embracing dual roles as disciplinary experts and pedagogical practitioners (Moore et al., 2015; Radzali et al., 2018). This professional identity evolution is exemplified by one participant who perceived herself as engaging in "more like what a real educator should do" (Du et al., 2021). Through sustained engagement with SCL, instructors report significant improvements in pedagogical expertise. Instructor-level implications also manifest through adaptive modifications in their instructions following three distinct patterns: successful transition to SCL, strategic integration of innovative and traditional methods, and reversion to traditional delivery. Instructors experiencing positive emotional outcomes demonstrate greater persistence and commitment to SCL (Chance et al., 2020; Evenhouse et al., 2017; Ralston et al., 2017). These educators actively seek continuous improvement through systematic feedback collection and structured evaluation mechanisms. Some adopt hybrid approaches that strategically integrate traditional and SCL to address personal comfort and student expectations. Conversely, negative emotional experiences can precipitate instructional regression, leading educators to abandon SCL.

At the classroom level, implications are multifold, encompassing diverse cognitive, behavioral, and motivational outcomes resulting from pedagogical transformations. While acknowledging initial student concerns to pedagogical transitions, the literature predominantly identifies substantial positive impacts on engineering student development and academic performance. Students demonstrate significant development of transferable professional competencies in SCL, including critical thinking, problem-solving, cultural competency, communication skills, leadership abilities, project management expertise, and practical application of theoretical knowledge (Moore et al., 2015; Ralston et al., 2017; Tucker et al., 2013).

The transition from individual classroom practice to institutional change requires strategic administrative support and formal recognition (Chance et al., 2020; Du et al., 2021). This institutional scaling process typically involves formal curriculum revision, policy development, and resource allocation to support widespread adoption of innovative pedagogical approaches. Engineering educators also facilitate change through informal peer networks and collaborative mentoring relationships, disseminating practices by inviting and coaching colleagues to adopt innovative approaches. This grassroots diffusion strategy fosters communities of practice that sustain and expand pedagogical innovations beyond individual classrooms, creating institutional cultures that support continued educational transformation.

Engineering instructors extend their pedagogical impact beyond institutional boundaries through faculty learning communities and advancement of scholarly knowledge through empirical research and publications. Faculty learning communities serve as vital mechanisms for pedagogical development and knowledge sharing, with educators appreciating formal

gatherings focused on pedagogical discussions (Chance et al., 2020). Some educators demonstrate long-term commitment to advancing pedagogical knowledge through sustained research engagement despite temporary setbacks. As documented by Du et al. (2021), dedicated educators maintain their commitment to both practice and research, focus on developing expertise as both engineers and educators. These instructors transform their localized experiences into generalizable knowledge that benefits the broader engineering education community, amplifying the reach across institutions and contexts.

Based on the findings, this study synthesized a conceptual framework, shown in Figure 1, that illustrates the recursive relationships between facilitation challenges, emotional experiences and multilevel implications in SCL adoption among engineering educators. This dynamic nature of this framework underscores emotions as both consequences of pedagogical challenges and drivers of SCL sustainability, positioning affective experiences as central to understanding pedagogical change in engineering education.

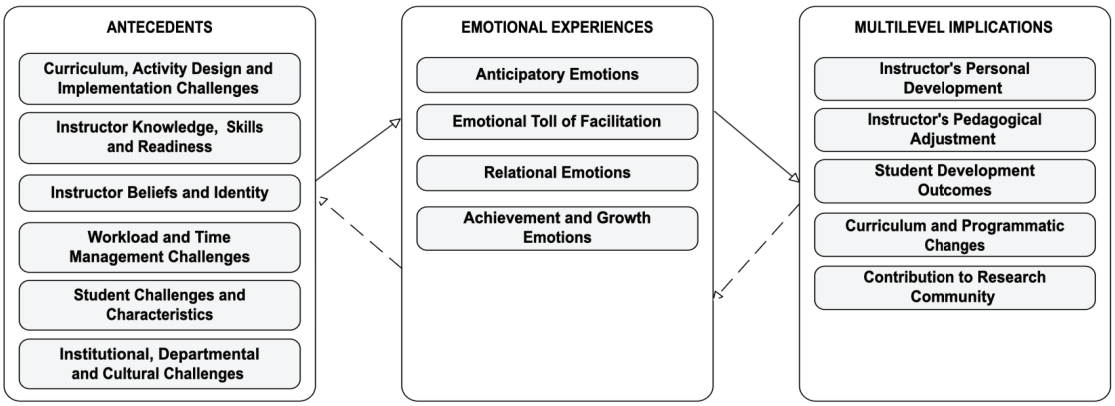


Figure 1: Engineering Educators Emotional Transformation Framework

Discussion

This study addresses the affective dimensions of facilitation among engineering educators, an area that has received limited scholarly attention despite its critical importance to pedagogical effectiveness. Through systematic synthesis of nine qualitative research studies, this analysis reveals three interconnected conceptual domains: facilitation challenges encountered, their emotional experiences during pedagogical transitions, and the multilevel implications of these phenomena. These findings fundamentally challenge the traditional characterization of engineering as an emotion-free discipline by informing the rich emotional landscape inherent in engineering pedagogical practices (Lönngren et al., 2024). As engineering educators adopt new teaching approaches, they engage in a process of learning that aligns with Mezirow's transformative learning framework, where individuals critically examine their assumptions and beliefs to develop new perspectives. Our research corroborates past scholarship highlighting a significant gap in transformative learning theory concerning its inadequate consideration of emotional experiences (Ali & Tan, 2022; Dirkx, 2001; Taylor, 2001). This represents a critical theoretical limitation, as emotions appear to play a central role in catalyzing and sustaining pedagogical change among engineering educators.

The findings indicated that engineering educators encounter a variety of challenges in facilitating students, including curriculum design difficulties, pedagogical skill deficits, student-related challenges and institutional barriers, that could trigger diverse emotional responses. Engineering educators experience both detrimental and beneficial emotional trajectories during their transition to facilitator roles. These emotional experiences function as what Mezirow (1991) describes as "disorienting dilemmas" that catalyze professional identity transformation, demonstrating how affective responses serve as crucial drivers of pedagogical development rather than mere byproducts of change. The negative emotions identified

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(anxiety, overwhelm, frustration) mirror patterns documented in teacher stress research, where accumulated negative emotions lead to burnout and compromised wellbeing that ultimately undermine job satisfaction and teaching effectiveness (Skaalvik & Skaalvik, 2016). This suggests that engineering educators adopting facilitative pedagogies face similar emotional risks, making emotional support particularly crucial during pedagogical transitions. Notably, positive epistemic emotions (curiosity, exploratory interest) and achievement emotions (joy, satisfaction) serve as both motivational drivers and reinforcement that encourage engineering educators to embrace and sustain their evolving roles as facilitators, creating a feedback loop essential for professional growth and pedagogical innovation (Frenzel et al., 2021). This convergence indicates that fostering positive emotional experiences during pedagogical transformation may be critical for long-term adoption of SCL. Although this literature cannot establish direct causal relationships between emotional experiences and their implications, it demonstrates the potential scope and impact of these phenomena.

Consistent with transformative learning theory, this conceptual analysis positions engineering educators' professional identities as central to their pedagogical transformation. Engineering educators' identities are inherently dynamic and susceptible to transformation as they navigate the complex intersection of their engineering and educational roles (Winberg, 2008). This identity evolution process is particularly challenging because engineering educators typically enter academia as disciplinary experts rather than trained pedagogical practitioners, creating a fundamental misalignment between their established professional identities and the demands of facilitative teaching approaches. The emotional experiences identified in our study, from initial anxiety and curiosity to frustration and eventual satisfaction, appear to serve as catalysts for this identity reconstruction, prompt critical reflection on existing assumptions about teaching and learning. This suggests that identity transformation in engineering education is not merely cognitive but deeply emotional, requiring educators to reconcile their technical expertise with evolving pedagogical competencies.

Departmental culture significantly influences individual educators' willingness to embrace pedagogical innovation. When teacher-centered beliefs dominate departmental norms, instructors often hesitate to initiate or sustain pedagogical changes, prioritizing collegial acceptance. This reluctance reflects the situated nature of professional identity development, which Narayanan (2022) describes as a dynamic process continuously recreated through community-based practice and shaped by multifaceted stakeholder interactions including students, colleagues, administrators, industry partners, and policy frameworks. Given this complex web of influences on identity formation, the process of professional identity reconstruction necessitates comprehensive socio-environmental support systems that not only facilitate professional development but also provide emotional scaffolding to help educators navigate the vulnerability inherent in questioning established teaching practices and embracing new facilitator roles. Thus, we propose that engineering educator development should fundamentally integrate emotional support with technical pedagogical skill development, recognizing that the transformation to facilitative teaching roles constitutes a complex identity reconstruction process. This requires creating institutional environments that not only acknowledge how individual emotional experiences cascade across classroom and institutional levels but also provide socio-environmental support systems that address both the cognitive and affective dimensions of pedagogical change.

Conclusions

This conceptual paper synthesizes key findings on engineering educators' facilitation challenges, emotional experiences, and their multilevel implications. The analysis reveals these domains are interconnected, with emotions serving as both consequences of pedagogical challenges and antecedents of subsequent teaching decisions. These findings challenge the predominant characterization of engineering as a 'rational-only' discipline by demonstrating the rich emotional landscape inherent in pedagogical practice. Complementing transformative learning theory with the affective dimension provides a critical perspective for

understanding pedagogical change in engineering education. The significance of emotions calls for faculty development programs that address both pedagogical knowledge and the emotional dimensions of teaching transformation. Successful pedagogical change requires systemic institutional support that acknowledges the emotional labor involved in innovative teaching practices. To advance knowledge in the field, future research should explore the intricate connections between pedagogical challenges, emotional experiences, and the pedagogical transformative process. Mixed-methods longitudinal research could provide rich data to explain the mechanisms involved in the process. This work envisions a paradigm shift toward emotion-inclusive engineering education that supports sustainable pedagogical innovation through comprehensive faculty development and institutional cultural change.

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