Who are the professional engineers participating in Continuing Engineering Education?

Understanding motivations and characteristics

Bente Nørgaard
Aalborg University, Denmark, bente@plan.aau.dk

Ellen Sjoer
The Hague University of Applied Sciences, Netherlands, e.sjoer@hhs.nl

Christopher J. M. Smith
Glasgow Caledonian University, United Kingdom, christopher.smith@gcu.ac.uk

Patricia Caratozzolo
Institute for the Future of Education, Tecnológico de Monterrey, Mexico, pcaratozzolo@tec.mx

Sonia Gómez Puente
Eindhoven University of Technology, Netherlands, s.m.gomez.puente@tue.nl

Katriina Schrey-Niemenmaa
Academic Engineers and Architects in Finland, TEK, Finland, katriina.schrey-niemenmaa@aalto.fi

Anna Overgaard Markman
Aalborg University, Denmark, Annaom@plan.aau.dk

Nicolaj Riise Clausen
Aalborg University, Denmark, Nclausen@plan.aau.dk

Abstract

The importance of Continuing Engineering Education (CEE) has increased significantly in response to rapid technological change, shifting industry standards, and the growing need for engineers to maintain up-to-date skills and competencies. Despite this, limited attention has been paid to understanding the profiles, career trajectories, motivations, and beliefs of the engineers who actively engage in CEE.

This study explores the motivations and characteristics of professional engineers participating in CEE across various European countries. It seeks to answer the research question: Who are the professional engineers participating in CEE, and what factors influence their decision to engage? Given the limited existing literature, an exploratory qualitative research design was employed. Semi-structured interviews were conducted with a diverse group of mid-career engineers from different disciplines, employment sectors, and national contexts. This approach enabled a deeper exploration of individual experiences and perspectives while allowing for flexibility in probing emerging themes. A total of eight interviews were conducted, focusing on participants' educational and professional backgrounds, their engagement with CEE, and their views on learning and professional development.

The study's findings provide valuable insights into how and why engineers engage in CEE, highlighting the importance of personal relevance, career alignment, and organizational context. The results can support CEE providers in developing more targeted and responsive learning opportunities that reflect engineers' aspirations, preferences, and professional realities. Ultimately, the study contributes to the broader dialogue on lifelong learning in engineering by emphasizing the diverse and evolving nature of CEE participation across Europe.

Keywords: Continuing Engineering Education (CEE); Continuing education; Professional engineers; Qualitative study; Motivation; Lifelong learning; professional development; Engineering education; Adult learning.

1 Introduction

The field of engineering is evolving at an exceptional pace, driven by rapid advancements in artificial intelligence (AI), Industry 4.0, and digitalization more broadly. These technological transformations are reshaping engineering practices, creating both significant opportunities and complex challenges. Among these challenges, the urgent demand for sustainability has become a central concern, positioning engineers as key actors in addressing the global environmental crisis (Chakrabarti et al., 2021). In this dynamic context, the need for Continuing Engineering Education (CEE) has become more critical than ever.

In this study, CEE is explicitly defined as the upskilling, reskilling, and ongoing development of competencies within the technical domain of engineering, explicitly excluding managerial or general leadership training. This definition reflects the study's focus on engineers' continued development of core technical expertise in response to a rapidly changing professional landscape.

CEE plays a vital role in equipping engineers with the skills and knowledge required to adapt to these evolving demands. However, despite growing recognition of its importance, current research in the field has primarily focused on the content, delivery formats, or effectiveness of CEE programs. Much less attention has been given to "who" participates in CEE and "why" they choose to engage. Yet, understanding the characteristics and motivations of the engineers themselves is essential. Such insights can support educational institutions, employers, and policymakers in designing more relevant and targeted learning experiences.

For engineers with over seven years of professional experience, typically considered mid-career, CEE is particularly important (Villanueva Alarcón, 2023). These professionals often face increasing expectations to keep up with technological developments while also balancing responsibilities in project management, mentoring, or leadership. Yet, many engineers in this demographic do not engage sufficiently in formal continuing education. A persistent disconnect between academic institutions and industry exacerbates this gap. While universities may lack current insight into industry demands, practicing engineers may have limited access to up-to-date academic knowledge that could inform their work (Villanueva Alarcón, 2023). Additionally, many small and medium-sized enterprises (SMEs) lack clear strategies for ongoing competence development among their engineering staff (Harper, 2021).

Another relevant dynamic is the trend among engineers to pursue management-focused education, often at the expense of continued technical specialization (Srour et al., 2013). This shift reflects broader career planning strategies, in which engineers are increasingly seeking to integrate technical expertise with leadership responsibilities. Furthermore, in many European countries, including the UK and Ireland, professional recognition through chartership requires ongoing engagement in CEE, underscoring its significance as a marker of professional development and commitment.

By gaining a clearer understanding of who participates in CEE and what drives them, educational providers can better tailor their offerings, both in terms of content and delivery, while industry stakeholders can be more effectively engaged in supporting professional development. To date, limited research has offered detailed insight into the profiles, motivations, and decision-making processes of engineers actively participating in technical CEE. Key questions remain underexplored: Who are these engineers? What motivates them to pursue further education in such a rapidly evolving field? What factors (personal, professional, or structural) influence their participation?

This study aims to contribute to the existing knowledge gap by providing an understanding of the engineers who engage in CEE and the factors that shape their participation. These insights can support

the creation of more targeted, responsive, and sustainable learning ecosystems that can adapt to the evolving demands of the engineering profession. This study addresses the following research questions:

What are the characteristics of the professional engineers participating in Continuing Engineering Education (CEE) in Europe?

What are the factors that influence the decision of the professional engineers to engage in CEE activities?

By addressing these questions, the research seeks to inform policy, guide educational practice, and support the development of a more integrated and future-ready system for lifelong learning in engineering.

2 Theoretical Framework and Methodology

This study is anchored in adult learning theory, which provides a comprehensive lens for understanding how professional engineers engage with continuing education. Adult learning theory involves a range of perspectives that underline the unique characteristics, motivations, and contexts of adult learners. A central belief in adult learning theory is the recognition of adults as self-directed learners (Knowles: 2005, Clausen: 2023), who are often driven by internal motivations and where the learning is typically experience-based (Kolb, 2014), with adults drawing on prior knowledge to contextualize and integrate new knowledge. The theory also stresses the importance of being goal-oriented, where educational activities are closely aligned with real-life challenges and professional demands.

Within this broader framework, Knowles' concept of andragogy highlights key principles such as autonomy, experiential learning, and the immediate applicability of knowledge (Knowles 1980). These principles are particularly relevant in the context of engineering professionals, who often seek learning opportunities that are tailored to their specific roles and responsibilities. Moreover, Illeris underscores the role of motivation as a driving force in adult learning (Illeris, 2004), aligning with broader theories such as self-determination theory (Ryan & Deci), which view motivation as essential to sustained engagement and meaningful learning outcomes.

These theoretical perspectives directly inform the three key areas of analysis in this study: motivations; experiences and perceptions and future expectations and recommendations. Knowles' emphasis on autonomy and goal-orientation helps illuminate why engineers choose to engage in continuing education, while Illeris' focus on cognitive, emotional, and motivational dimensions provides a framework for understanding how they experience and make sense of that learning. Furthermore, both theories support a forward-looking view of adult learning that is adaptive and learner-centered, offering valuable insight into participants' expectations for future CEE programs and their recommendations for improving relevance, flexibility, and impact.

This study employs a qualitative, exploratory research design to investigate the motivations and characteristics of professional engineers who participate in Continuing Engineering Education (CEE) across various European countries. The qualitative approach is well-suited to explore the nuanced, personal, and career-related factors that influence engineers' decisions to participate in CEE, as well as to gain a deeper understanding of their professional profiles (Creswell, 2009). Data were collected through semi-structured interviews, which allowed for in-depth exploration of individual experiences, perspectives, and motivations (Iii & Hagstrom-Schmidt, 2022). This format provided the flexibility to adjust the line of questioning based on participants' responses, enabling the interviewer to probe deeper into emerging themes while maintaining a consistent focus on the core research questions related to CEE participation (Buys et al., 2022). The interview guide was developed drawing on findings from the Nordic Engineering

Hub project (2018–2021) and the authors' extensive experience within the field of CEE. The guide included open-ended questions that addressed factors influencing participation, personal and professional motivations, experiences, and perceptions of CEE, as well as participants' expectations and recommendations for future development.

A total of eight mid-career professional engineers from various engineering disciplines, employment sectors, and geographical regions (Denmark, Finland, the Netherlands, and the United Kingdom) were purposively selected to participate in the study. Participants were included based on the criteria of being mid-career professionals, defined as having more than seven years of work experience, and actively engaged in engineering-specific Continuing Engineering Education (CEE), excluding management or leadership training. The participant's background characteristics are listed in Table 1.

Table 1: Participants' background characteristics

Respondent	1	2	3	4	5	6	7	8
Age	46	35	38	38	35	40-49	44	47
Gender	F	M	M	F	F	M	M	M
Nationality	DK	NL	NL	FI	FI	UK	NL	NL
SME/LE	LE	LE	LE	LE	LE	LE	LE	SME

Interviews were conducted in early spring 2025 by the authors. Interviews were conducted both in-person and online, with each lasting between 20 and 60 minutes. All interviews were recorded with participants' consent and subsequently transcribed. To comply with data protection protocols and institutional legislation, the authors who conducted the interviews also carried out the initial data analysis using a shared analysis template. The template was designed to reflect the structure of the interview guide, organizing the data according to major thematic areas. Through iterative analysis and cross-comparison, key themes were refined and substantiated with representative excerpts from the data.

The analysis is structured around three overarching themes:

- Motivations for participation in CEE
- Experiences and perceptions of CEE
- Future expectations and recommendations

Ethical approval for the study was obtained from each author's institution. All participants provided informed consent before their involvement and were assured of the confidentiality and anonymity of their responses. Audio recordings were securely stored and were accessible only to the researchers. Participants were informed of their right to withdraw from the study at any point without consequences.

3 Analysis and Findings

This section presents the initial thematic analysis of insights from eight semi-structured interviews conducted with mid-career professional engineers across Europe. The study explores common patterns and contrasts in how these individuals perceive, approach, and experience continuing education (CEE). The following five overarching themes emerged in the exploratory analysis.

3.1 Structured planning to organic growth: Diverse motivations for CEE participation

All participants in the study considered CEE a meaningful component of their professional lives; however, their approaches to engaging in learning varied significantly. For some, CEE was deeply embedded within structured annual planning processes. One respondent (P1), for instance, routinely assessed upcoming skill gaps, both her own and those of her team, and actively sought relevant courses to address them pre-

emptively. This forward-looking strategy was part of a broader organizational practice of aligning learning objectives with anticipated project responsibilities and competence demands.

Others (P5, P6, P7, P8) adopted a more emergent or interest-driven approach, responding flexibly to evolving work contexts or intrinsic curiosity. One (P1) engineer described her learning trajectory as an ongoing process of adaptation, where decisions to participate in CEE were often made informally in response to new challenges or areas of intrigue. For her, CEE functioned less as a strategic instrument for career progression and more as a tool for staying mentally engaged and intellectually stimulated.

These differences highlight two somewhat distinct orientations toward CEE: a careerist, goal-driven mode of engagement and a more organic, interest-led model. Some (P1, P3, P7) viewed CEE as essential to positioning themselves for managerial roles and broader responsibilities, while others emphasized deepening existing knowledge or maintaining technical fluency in rapidly evolving fields.

In addition, some participants holding supervisory or integrative roles (P1, P4) often described CEE as a necessity for maintaining a broad, systems-level understanding of emerging technologies. One such respondent (P4) emphasized the importance of grasping the "big picture" to assess whether team solutions were technically relevant. At the same time, another (P1) discussed her role as a translator between state-of-the-art research and practical implementations. These insights suggest that while CEE is widely valued, the motivations for pursuing it are multifaceted and shaped by role, responsibility, and personal orientation.

3.2 Organizational support: A spectrum from empowerment to self-advocacy

All respondents indicated that their employers supported CEE to some extent, but the nature, extent, and effectiveness of this support varied considerably. In several of the organizational settings (P1, P2, P3, P6), CEE was integrated into annual review processes, supported by structured planning tools such as development plans or collective competency matrices. These environments enabled participants to engage in learning with relative ease, often during work hours and with costs covered. One (P2) participant noted that participation in CEE was expected and facilitated, with a wide array of internal and external courses made available by their HR department.

In other (P5) cases, however, support mechanisms were more loosely defined, requiring individual initiative and negotiation instigated by the participant. One (P3) participant described having to advocate for learning opportunities and make strategic decisions about which courses to prioritize due to time constraints. Even in organizations where CEE was theoretically encouraged, work demands sometimes overshadowed learning intentions. One (P6) respondent highlighted this tension, stating that while he was technically allowed to attend courses during work hours, the pressure of ongoing responsibilities often made it challenging.

Notably, these differences were not necessarily tied to industry or geography. Still, they appeared to stem from variations in local management cultures and the degree to which CEE was seen as a legitimate and prioritized component of professional work. For example, while one participant (P1) described a workplace culture where CEE was seamlessly woven into the rhythms of everyday activity, another (P3) felt that participation required justification and compromise despite formal policies suggesting otherwise. Another (P6) participant reported that management was unsupportive to the point where he thought he was being sabotaged in his CEE efforts at one stage in his career. However, this individual felt so strongly about self-development that he made it work.

These accounts reveal a spectrum of organizational experiences, ranging from highly supportive ecosystems to more contingent arrangements where engineers must strategically navigate learning amid competing demands. They also underscore the importance of not just providing access to and time for

CEE but ensuring that the organizational culture meaningfully values and integrates it into the professional workflow.

3.3 Juggling priorities: Balancing time, family, and learning

Time, not surprisingly, emerged as a near-universal constraint on CEE engagement for all participants, yet how participants managed this constraint varied in accordance with their responsibilities, job roles, and obligations from their personal lives. Several (P3, P4, P5) engineers with young children pointed to the challenge of balancing family obligations with the demands of both work and CEE. In these accounts, time was not just a scarce resource; instead, it was a source of tension that required continuous negotiation and adjustment.

For some (P1, P2, P3), supportive employers and flexible work arrangements provided room to engage in CEE during working hours. One participant (P4) described a well-integrated schedule that allowed her to attend courses without significant disruption to her work or family responsibilities. For others (P3), even when the employer nominally supported CEE, the practical realities of project deadlines or team obligations made it almost impossible to dedicate sufficient time to CEE. These participants often found themselves studying during evenings or weekends, a compromise that, while manageable for some, added additional stress.

The contrast between those who viewed CEE as smoothly integrated into their weekly routines and yearly planning and those who experienced it as a burden to be absorbed outside regular hours illustrates how work-life context significantly impacts learning behavior. Some (P7, P8) engineers described that while they participate in both internal and external training requested for their jobs, they also engage in more sporadic additional CEE, participating when time allowed, while others (P1, P2, P3, P6) maintained a more consistent rhythm, enabled by personal time management strategies and organizational support. Interestingly, several participants (P1, P3, P7, P8) reported developing informal strategies to cope with time pressures, such as embedding learning into project workflows, utilizing CEE activities as a platform for reflection, or incorporating reading and self-study during commute times. These adaptive strategies highlight the ingenuity with which mid-career professionals reconcile learning with other responsibilities. Still, they also underscore the need for CEE offerings that accommodate the lived realities of adult learners. Another (P6) participant reported that their priority of CEE and the lack of company support to participate in it during work hours at one point in their career played a significant role in their decision to seek other employment, even though all other aspects of their work were agreeable.

3.4 Personalized learning preferences: Collaborative engagement and solitary study

A consistent theme across the interviews was the participants' preference for CEE formats that aligned with their learning behaviors. However, there was considerable variation in what their preferences entailed. While most of the engineers (P1, P2, P3, P4, P6, P7) favored interactive, group-based learning formats, such as in-person workshops, coaching sessions, or university partnerships, others (P4, P5, P8) found more excellent value in solitary, text-based study and individual reflection.

Most of the participants expressed a strong preference for face-to-face engagement, citing the value of discussion, feedback, and peer interaction as essential to the learning process. One participant (P1) suggested that the physical presence of others created a productive learning environment that could not be replicated online, while another (P6) pointed to the physical shift in location as paramount in avoiding disturbances from colleagues and other daily routines. A (P1) participant also mentioned hybrid approaches that blended short face-to-face seminars with more extended online modules or self-study. Flexible combinations were particularly appreciated by engineers navigating complex schedules, as they allowed for both in-depth exploration and pragmatic integration into daily routines. Another (P4)

respondent emphasized her aversion to audio or video-based materials and favored reading PDFs or handbooks that could be directly applied to the technical challenges of her daily work.

This divergence in format preference reflects broader differences in how participants positioned CEE in their professional lives. Those who viewed learning as a collaborative endeavor tended to value dialogue and exchange, often situating CEE within broader communities of practice and as part of an ongoing learning process. Others, especially those who described high workloads or limited time, gravitated toward more focused, efficient formats that could be tailored to their immediate needs.

Overall, these differences point to a key implication for CEE providers: engineers do not share a singular learning profile. Instead, their preferences are shaped by several factors, including personality, time constraints, learning goals, and prior experiences, which must be taken into account in the design and delivery of compelling CEE offerings.

3.5 Accessing state-of-the-art: Contrasting experiences with CEE content

A common motivation among participants was the desire to stay professionally updated, especially in areas characterized by rapid innovation, such as fiber composites, hydrogen technologies, and advanced simulations. However, the extent to which this desire could be fulfilled through the available continuing education offerings varied greatly among respondents.

Some (P1, P2) engineers reported difficulties in finding offerings that were both relevant and sufficiently up-to-date. One participant (P1) expressed frustration over the slow response of continuing education programs to technological advancements, arguing that many courses lag behind industry and field developments and fail to integrate new research. She (P1) emphasized the need for academic institutions to play a more proactive role in translating pioneering knowledge into accessible and practical learning opportunities for working professionals. In contrast, others (P3, P4, P5, P8) were more satisfied with the existing continuing education ecosystems, especially in countries with well-functioning frameworks for collaboration between universities and industry. For example, one (P5) engineer praised national initiatives that offered modular and stackable courses tailored to new industry needs. These offerings, often facilitated through university networks, enabled participants to acquire micro-competencies and gradually build specialized knowledge.

It is also significant that participants differed in their approach to navigating the landscape of continuing education opportunities. Some adopted a highly self-directed approach, utilizing personal networks, professional associations, and online platforms to identify relevant learning opportunities. Others were more dependent on institutional channels such as internal course catalogs or recommendations from managers. While the former group (P1, P4, P5, P7, P8) seemed better at managing their learning journey, the latter (P2, P3) more often aligned their interests with the needs of their employers in choosing CE opportunities.

These accounts reflect a dual challenge for providers of continuing education for engineers: They must not only ensure that content aligns with technological developments but also support participants in finding and accessing relevant opportunities.

4 Discussion

All participants in the study considered Continuing Engineering Education (CEE) a meaningful part of their professional lives. This is an overall positive response, as research and future studies consistently highlight the need for skills and competence development within all areas of engineering. However, as seen from the analysis, these positive attitudes are challenged by factors such as organizational structure, motivation, learning preferences, and the provision of CEE.

To synthesize these findings, Table 2 highlights the main dimensions, participant experiences, and implications for practice:

Table 2: Dimensions and implications for practice.

Dimension	Findings	Implications for practice
Motivations for CEE	Engineers are engaged either through structured, career-driven planning (often in larger firms with competence strategies) or through emergent, interest-driven learning (common in medium-sized enterprises (SMEs)). Participation was shaped by personal relevance, intrinsic motivation, and the need to remain qualified (e.g., chartered engineer requirements).	CEE must accommodate both strategic, career-oriented learners and flexible, interest-driven participants. Policies should account for SME contexts where formal structures are rare.
Organizational Support	Experiences vary widely: some participants had access to fully integrated CEE with company funding and time allocated during work hours; others relied on personal initiative and negotiation. In regions with charter systems, unions and institutions play a stronger role in provision.	Companies should embed CEE into strategic planning and organizational culture to ensure accessibility and sustainability.
Time & Work–Life Balance	Time was a universal constraint; engineers often studied outside work hours, creating stress and family conflicts.	CEE should be integrated into workflows (e.g., PBL and work-based learning) to reduce additional burden on professionals and enhance relevance.
Learning Preferences	Preferences were diverse: many favored interactive, group-based formats such as in-person workshops, coaching, or university partnerships. Others preferred a solitary, text-based study. Face-to-face engagement and peer interaction were strongly prioritized, with online courses and micro-credentials attracting little interest despite their availability.	Providers should offer a mix of formats, interactivity, and opportunities for peer learning. Over-reliance on generic online modules risks disengagement.

Access to Relevant & Updated Content	Some participants reported outdated offerings that lag behind industry developments. Others highlighted positive experiences with modular and stackable courses, often developed through strong university-industry collaboration.	Faster translation of emerging knowledge into practice is needed. Expanding modular, industry-aligned, and collaborative course design will help ensure engineers remain competitive in rapidly evolving fields.
Theoretical Alignment	Findings resonate with adult learning principles: Knowles' andragogy (self-directed, goal-oriented learners), Illeris' emphasis on motivation and meaning, and Kolb's experiential learning through problem-solving.	CEE design should foreground adult learning theory by ensuring content is relevant, flexible, situated in practice, and meaningful to learners.

A forward-looking strategy, where skill and competence needs are aligned with company strategic development and learning activities are integrated into work processes, represents a highly organized and structured approach. This method is often applied in larger companies with well-defined competence strategies and the resources to implement such an approach. However, in the EU, where more than 99% of companies are small and medium-sized enterprises (SMEs), this is not the typical experience of the average engineer. For many, CEE is more likely to be emergent or interest-driven, as 50% of the EU's workforce is employed in SMEs (Eurostat, 2022).

How individual engineers navigate, structure, and plan their CEE is highly influenced by their employment context. Whether it involves structured planning or more ad hoc, organic growth likely depends on the extent of strategic competence development and who bears the costs. However, regardless of the opening, there are fundamental characteristics that define how adults approach learning. As Illeris (2006) states, "Adults learn what they want to learn and what is meaningful for them to learn." This highlights a crucial point: participation in CEE is rarely about compliance or obligation alone. Instead, it is influenced by personal relevance, intrinsic motivation, and the perceived value of the learning experience.

Learning preferences among participants were diverse. There was a strong preference for face-to-face engagement and peer interaction, with some engineers emphasizing the importance of a physical shift in location to avoid disturbances from colleagues and daily routines. Those who view learning as a collaborative endeavor value dialogue and peer feedback. In contrast, engineers with high workloads or limited time prefer more focused and efficient formats tailored to their direct needs. Surprisingly, in-person learning activities are highly prioritized, with little interest in online courses or micro-credentials despite their prevalence in the current CEE landscape.

Several respondents reported significant challenges in finding CEE offerings that are both relevant and sufficiently up to date. Participants emphasized the need to translate pioneering knowledge into accessible and practical learning opportunities for working professionals. This is particularly evident in countries with well-functioning frameworks for collaboration between universities and industry, which facilitate the development of courses aligned with current industry needs.

These findings show that CEE is shaped not only by individual motivation but also by structural opportunities and constraints within organizations, and they are well aligned with adult learning theory, which emphasizes the self-directed and goal-oriented nature of adult learners (Knowles, 2005), as well as

the importance of internal motivation and meaningful application (Illeris, 2006, Ryan & Deci, 2000). The challenges engineers face in balancing time, family, and learning further reinforce Knowles' and Illeris' emphasis on the need for education that is relevant, flexible, and situated within real-life contexts. Additionally, the diversity of learning preferences observed in this study reflects Kolb's (2014) experiential learning theory, which underscores the value of accommodating different learning styles through varied instructional approaches.

5 Conclusion

This study highlights the importance of Continuing Engineering Education (CEE) as a vital component of professional development for engineers. Despite the widespread recognition of its value, approaches to engaging in CEE vary significantly, shaped by organizational support, personal motivations, and individual learning preferences. As such, CEE providers must offer a range of learning formats - from interactive, group-based sessions to individualized study options - to support sustained engagement. Addressing these challenges and aligning offerings with adult learning principles will help ensure that engineers remain competitive and well-equipped to navigate the evolving technological landscape.

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