Proceedings of the Design Society, Volume 6: DESIGN 2026
https://doi.org/10.1017/pds.2026.10669

Using guidelines to train key users: accelerate skills development during a CAD/PDM software transition

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ABSTRACT: During the transition to CAD/PLM software, key users underwent guideline-based training aligned with company workflows. This practical approach, which linked tool functions to real design practices, accelerated the acquisition of skills, ensured modelling consistency, and improved understanding of digital engineering. The study identifies key users as knowledge multipliers and reveals how such methods develop competence. The findings emphasise the significance of problem-solving training and the relevance of guideline-based methods for industrial practice and design education.

KEYWORDS: computer-aided design (CAD), product lifecycle management (PLM), software transition, guideline-based training, key users skills

1. Introduction

The increasing digitalisation of engineering design has led to the widespread adoption of complex software ecosystems integrating computer-aided design (CAD) and product lifecycle management (PLM) systems. These software platforms play a central role in how organisations conceptualise, model, validate and manage engineering data throughout the product lifecycle (Ameri & Dutta, 2005; Fielding et al., 2014). However, when companies transition from one CAD/PLM environment to another, the change has far-reaching implications that extend beyond the technical migration (Garetti et al., 2005). Successful transitions therefore depend on effective learning strategies that enable designers to adapt their skills and maintain productivity, as well as on software implementation.

The digital transformation in engineering education and industry further amplifies the need for adaptive learning. As organisations adopt increasingly interconnected CAD/PLM ecosystems, designers must master new interfaces and understand data standards, collaborative workflows, and lifecycle-oriented practices. These demands mirror the challenges encountered in design education, where curricula must evolve to prepare learners for complex socio-technical environments rather than the use of isolated tools. Consequently, training strategies that integrate technical, procedural, and organisational dimensions are essential for maintaining performance during software transitions.

Traditional software training approaches, which often focus on tool-centric tutorials or isolated functions, have been found to be ineffective in facilitating the application of knowledge in real design scenarios. Project-based learning, for instance, has been shown to be more effective than purely tool-based training in supporting competency development in CAD/CAM/CAE education (Sola-Guirado et al., 2022). In contrast, contextualised and problem-based learning emphasise the importance of acquiring skills through real engineering tasks (Kolb, 1984). Within this framework, guidelines – defined as structured documents that codify best practices, modelling standards, and workflow conventions – can serve as mediating artefacts between abstract software knowledge and practical design reasoning. They help learners connect the functionalities of new tools to familiar engineering principles and internalise modelling strategies that align with company or project standards.

https://doi.org/10.1017/pds.2026.10669 Published online by Cambridge University Press

Key users play a pivotal role in this learning process. Acting as intermediaries between various stakeholders, including system developers, IT specialists and end users, they are responsible for translating technical features into operational practice and disseminating expertise across teams (Kung et al., 2015). Their ability to adopt and communicate new knowledge effectively is crucial to the success of new software implementation. However, despite their importance, few studies have examined how targeted, guideline-based learning frameworks can accelerate key users' competency development and foster organisational learning during CAD/PLM transitions.

This paper examines how guideline-based training can strengthen the skills of key users when implementing a new CAD/PLM environment in an industrial context. The approach aims to bridge the gap between technical instruction and practical application by aligning training materials with real design workflows and emphasising hands-on, problem-solving activities. Beyond its industrial relevance, the study also considers how the approach could inform design education curricula, supporting the development of adaptive, workflow-oriented competencies among future designers. The findings will inform current discussions on digital design instruction, experiential learning and competency-based technical education in an ever-changing technological landscape.

Aiming to address the educational and organisational dimensions of this transition, the paper describes the development and application of guidelines and presents examples of their content. It also explains how their effectiveness was evaluated in practice.

2. Background and theoretical framework

The increasing complexity of CAD and PLM tools in digital engineering requires designers to develop adaptable competencies that connect technical proficiency with problem-solving and reflective practice. This is closely aligned with competency-based education (CBE), which focusses on demonstrable abilities rather than knowledge acquisition alone (Eraut, 1994; Illeris, 2007). CBE frameworks emphasise authentic contexts where learners can integrate conceptual understanding, procedural knowledge and professional judgement. In the context of engineering design, this approach is crucial to ensure that employing digital tools remains grounded in meaningful design reasoning rather than repetitive execution.

2.1. Competency-based and Adaptive learning

Competency-based education (CBE) emphasises the integration of conceptual understanding, procedural skills, and professional judgement into demonstrable abilities (Eraut, 1994; Illeris, 2007). In the context of CAD/PLM training, this approach highlights the importance of learning activities that link software functions to meaningful engineering tasks.

Kolb's (1984) experiential learning cycle offers an additional perspective: learners progress through concrete experience, reflective observation, abstract conceptualisation, and active experimentation. When applied to digital design tools, this involves modelling realistic components, analysing the outcomes of actions and iteratively refining strategies.

Furthermore, Eraut (1994, 2000) emphasises that much professional learning occurs informally through guided participation, feedback and workplace practice. Illeris (2007) builds on this by demonstrating how the cognitive, social and emotional dimensions interact during the development of skills.

Together, these frameworks suggest that effective CAD/PLM training should be flexible, context-specific and practical. Rather than following fixed lesson sequences, learners should be given the opportunity to progress at their own pace, reflect on complex workflows and integrate new competencies into real-world situations.

2.2. Procedural knowledge and situated learning in design practice

A critical dimension of engineering expertise is procedural knowledge, which is defined as the know how embedded in actions and methods rather than declarative descriptions (Anderson, 1982). In CAD/PLM environments, procedural competence includes modelling strategies, naming conventions and workflow coordination. These routines form the backbone of design consistency and interoperability. However, this knowledge is rarely explicit, often being transmitted through mentoring, shared artefacts and societal interaction (Eraut, 2000).

Adopting the situated learning perspective proposed by Lave and Wenger (1991), learning occurs through participation in a community of practice. Rather than learning through abstract instruction,

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newcomers learn by engaging with authentic tasks under the guidance of experts. In the context of CAD/PLM transitions, for example, designers acquire competence by working on real models, observing expert practices and progressively taking responsibility for processes. Consequently, learning becomes inseparable from the professional context in which it occurs.

2.3. Guidelines as mediating artefacts in learning and standardisation

From a socio-cultural perspective, Vygotsky's (1978) concept of 'mediating artefacts' refers to tools and symbols that facilitate interaction between individual cognition and collective activity. In engineering design, guidelines fulfil this role by making tacit knowledge explicit, codifying shared conventions, and providing a structured reference for design procedures.

As boundary objects, they help to align diverse professional groups, such as engineers, managers, IT specialists and educators, by offering a common framework for interpreting modelling practices. This is particularly important in globally distributed organisations, where shared guidelines minimise ambiguity, reduce inconsistent interpretations and support coordinated work in multicultural, multilingual teams.

In learning contexts, these artefacts guide learners as they explore new software, helping them connect the functionalities of the tools with established engineering practices. Their dual role as standardisation instruments and cognitive supports makes them invaluable for training key users during software transitions. As such, guidelines can be assessed not only by learning outcomes, but also by how widely they are adopted and reused, and the role they play in fostering collective practice.

2.4. Integrative perspective

Combining these theories suggests that successful learning during software transitions depends on aligning competency-based objectives, situated practice and mediating artefacts. Guideline-based training offers a practical approach to achieving this alignment by structuring experiential learning (Kolb, 1984), facilitating workplace adaptation (Eraut, 1994) and encouraging reflection-in-action via shared artefacts (Vygotsky, 1978). This integrated framework forms the basis of the case study presented in the next section, which looks at how key users developed procedural and adaptive competencies through guideline-centred instruction during a CAD/PLM transition.

3. Methodology and context of the study

This section outlines the methodological framework and organisational context of the study. It provides an overview of the context of the software transition and the collaborative process involved in developing the guidelines, as well as the participatory role of key users in refining and validating them.

3.1. Context of the software transition

The study was conducted within a global company that operates in the food, beverage, and pharmaceutical industries. The organisation initiated a worldwide transition to a new, integrated CAD/PLM environment to improve interoperability between design and data management systems, as well as benefit from the unified support provided by a single software vendor.

This transition necessitated the redefinition of modelling practices and the adoption of a consistent approach to product data management across multiple regions. As the deployment affected design teams on different continents, it was essential to achieve consistent standards and shared workflows. Key users, experienced designers recognised for their expertise in specific domains, were therefore identified as central contributors. Their responsibilities included drafting guideline content within their area of expertise, validating methodological choices, and ensuring that the new practices could be transferred across global teams.

3.2. Collaborative and participatory development of the guidelines

It should be noted that, when the guidelines were drafted, the systems had not yet been fully implemented. This means that certain issues could be discussed during the drafting process, and those issues would then be addressed in the guidelines and adopted for implementation.

The development of the guidelines followed a structured and iterative process involving close collaboration between the company's internal project team and an external consulting group specialising

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in CAD/PLM consulting, training and e-learning. Initially, the internal project lead proposed a list of themes, each of which would correspond to a future guideline. These themes covered the CAD and PLM domains, as well as several cross-disciplinary topics that bridged both areas. Preliminary objectives were then outlined for each theme to clarify the intended scope and expected outcomes.

In a subsequent phase, this list was jointly reviewed with the external consulting team. Drawing on their extensive experience in industrial training and software implementation, the consultants suggested adjustments and refinements. The final set of topics therefore addressed both technical aspects, such as modelling conventions, feature structures and data management, and organisational dimensions, including workflow coordination, version control and inter-departmental communication.

The external team then prepared an initial version of each guideline, which was first discussed with the key user or users responsible for the relevant topic. During these discussions, the key users were able to benefit from the editorial team's expertise. The editorial team's prior involvement in similar projects meant they could provide relevant examples and best practices to facilitate software adoption and cross-site collaboration.

These discussion meetings also ensured that the proposed procedures were compatible with local working practices and the range of products. They fostered a participatory learning environment, turning the guidelines into living documents rather than top-down instructions. Through dialogue and negotiation, key users provided examples from their day-to-day work, identified ambiguous cases and confirmed the relevance of the recommendations.

Once the initial drafts had been validated, the guidelines were distributed to all key users for review. Feedback and improvement suggestions were collected and consolidated through several rounds of exchanges between the editorial team and the contributing and responsible key users. This iterative review process resulted in documents that combined the precision of formal guidelines with the contextual sensitivity of operating procedures. These documents served as both reference standards and learning artefacts, striking a crucial balance between strict standardisation, which would have limited flexibility, and purely descriptive procedures, which would not have ensured coherence across the organisation.

The process concluded with a plenary session involving all key users, the external editorial team and the internal project team leaders. This meeting was held to finalise the content, resolve any remaining ambiguities and formally adopt the guideline versions to be made available across the organisation.

Figure 1 illustrates the structured workflow of the guideline development process. It outlines the successive phases, from theme definition to final adoption, and shows how the different teams are involved at each stage. This workflow provides a structural reference for the collaborative and participatory process described earlier, in which the content of the guidelines was progressively defined, drafted, reviewed and validated through the coordinated contributions of the various stakeholder groups.

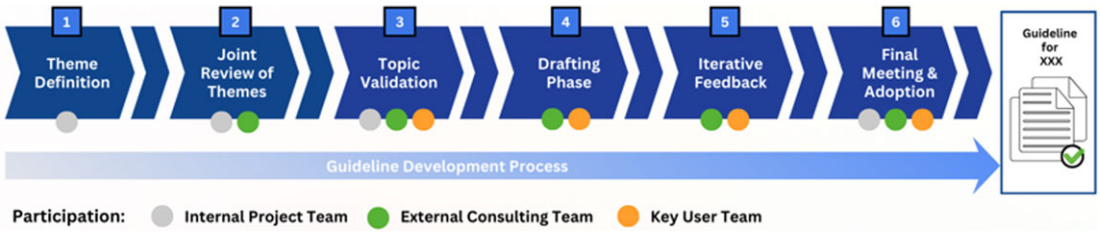


Figure 1. Workflow of the collaborative guideline development process

3.3. Methodological approach

This study can be characterised as having an action-oriented design research methodological orientation (Blessing & Chakrabarti, 2009; Wieringa, 2014). Rather than testing hypotheses in isolation, this approach examined the processes of learning and knowledge construction as they unfolded during implementation. Data were gathered through project documentation, meeting notes, participant observations and informal interviews with members of the key user network and the drafting team. Qualitative analysis focussed on how the creation and discussion of guidelines contributed to the development of competence, the establishment of a shared understanding, and the alignment of design practices.

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This methodological framework enabled the study to capture both the organisational dimension of the transition, namely collaboration between internal and external stakeholders, and the pedagogical dimension, as in learning through artefact creation and negotiation. The next section describes how the guideline-based training was implemented in practice and its impact on the learning experience of key users.

3.4. Data collection and evaluation criteria

The guideline-based training was evaluated using qualitative and descriptive indicators collected during the implementation phase. Data sources included:

- Structured feedback provided by key users during guideline review cycles;
- Observations recorded during online workshops and review meetings;
- Documented revisions of guideline content resulting from some user feedback;
- Comparative reflections reported by participants based on previous software transition using a different training approach.

A total of twelve (12) key users from business units in four (4) different countries and three different continents participated actively in the evaluation process. Two (2) members of the internal project team provides additional feedback during the guideline review cycles. The remaining nine (9) members of the editorial team – those who did not prepare the discussed guideline – took part in discussions during online workshops and review meetings, proposing suggestions based on their experience of other projects. Feedback was collected continuously over a three-month period and included both positive assessments and critical remarks. Although the study did not aim to produce statistically generalisable results, triangulation of multiple data sources enabled robust interpretation of the perceived cognitive, operational and organisational effects.

4. Implementation of guideline-based training

The guideline-based training approach combined self-directed learning with authentic practice in the daily work environment of the key users, reflecting the project's educational orientation, which prioritised learning through experience, reflection and collaboration over traditional classroom instruction. The training phase aimed to enable participants to understand the new CAD/PLM tools and test and refine the accompanying guidelines under realistic design conditions (Boud & Solomon, 2003).

4.1. Training structure and process

The training was conducted entirely online to accommodate the company's geographically dispersed teams. Each key user received access to the full set of guidelines and was invited to study them progressively for three months. Rather than following a predefined sequence, users could determine their own order of study depending on their business unit's priorities and the design topics most relevant to their work. This flexible structure reflects the project's adaptive learning philosophy (Illeris, 2007) and the principles of adult self-directed learning (Knowles et al., 2020). It promotes autonomy and ownership of the learning process.

During this period, each key user was instructed to apply the content of every guideline to at least one example from their own work, typically an existing model, assembly or workflow used in current projects. As the key users had simultaneous access to the existing software systems and the forthcoming CAD/PLM platform, they could compare the two directly and assess how well the proposed recommendations aligned with real design needs. This approach embodied Kolb's (1984) experiential learning cycle, encouraging cycles of experimentation and reflection within authentic work contexts.

4.2. Integration of guidelines in daily practice

The guidelines acted as mediating artefacts (Vygotsky, 1978) connecting conceptual understanding with procedural performance. Rather than being conceived as prescriptive rules, they were seen as reference frameworks to be tested, adapted and discussed. By applying them to specific design tasks, users transformed written standards into practical knowledge. This process mirrored the situated learning dynamic described by Lave and Wenger (1991) and elaborated upon through the notion of communities

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of practice (Wenger, 1998), whereby knowledge develops through legitimate participation and social negotiation.

Testing the guidelines in a real work environment had two benefits: it validated the technical feasibility of the proposed specifications and revealed inconsistencies or ambiguities that might not emerge during a traditional training session. Thus, the learning and standardisation processes became intertwined; learning served to refine the guidelines and the guidelines structured the learning (Tynjälä, 2008).

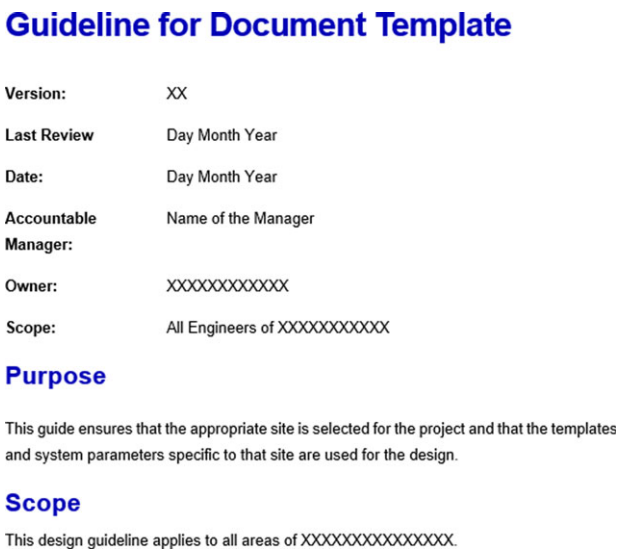
4.3. Feedback and iterative improvement

To facilitate ongoing communication, a dedicated email address was set up where participants could submit their comments, questions and suggestions for improvements. Messages sent to this address were received by both the internal project leaders and the external editorial team, enabling prompt and coordinated responses. The feedback covered a wide range of topics.

Based on this 'feedback', the editorial team revised several guidelines to better reflect the working practices observed during the testing phase. Once the updated versions had been distributed, key users expressed high levels of satisfaction, noting that the guidelines had helped them to maintain a familiar workflow dynamic while improving data consistency and modelling quality. Overall, the outcome confirmed the value of collaborative revision as a mechanism for collective learning and organisational adaptation (Eraut, 2000).

4.4. Structure and examples of guidelines

Each guideline document begins with a front cover, followed by an introductory page providing essential contextual and administrative information (see Figure 2). This page includes the title of the guideline, its version number, the date of the last review, the accountable manager, the owner and the scope of application. By clearly identifying responsibilities and applicability, the guideline establishes itself as a controlled and maintained reference document. A short purpose statement summarises the intent of the guideline and the design or workflow issue it addresses, enabling users to swiftly determine its relevance before consulting the detailed content.



Guideline for Document Template

Version:	XX
Last Review	Day Month Year
Date:	Day Month Year
Accountable Manager:	Name of the Manager
Owner:	XXXXXXXXXXX
Scope:	All Engineers of XXXXXXXXXX

Purpose

This guide ensures that the appropriate site is selected for the project and that the templates and system parameters specific to that site are used for the design.

Scope

This design guideline applies to all areas of XXXXXXXXXXXXXX.

Figure 2. Example of a guideline introductory page (Hidden information is deliberately concealed.)

Figure 3 illustrates the variability of guideline content, combining three (3) representative examples. Some guidelines are intentionally concise, addressing a narrowly defined topic and providing targeted recommendations for quick reference during daily work. Others are more extensive, covering broader engineering domains and structuring their content into multiple chapters ranging from fundamental principles to detailed implementation aspects. A third category focusses on workflows and usage, combining steps, responsibilities, and interactions between CAD and PLM. All guidelines follow a common logic, regardless of their length or structure. This allows them to function as learning and standardisation resources while remaining adaptable to the complexity of the topic.

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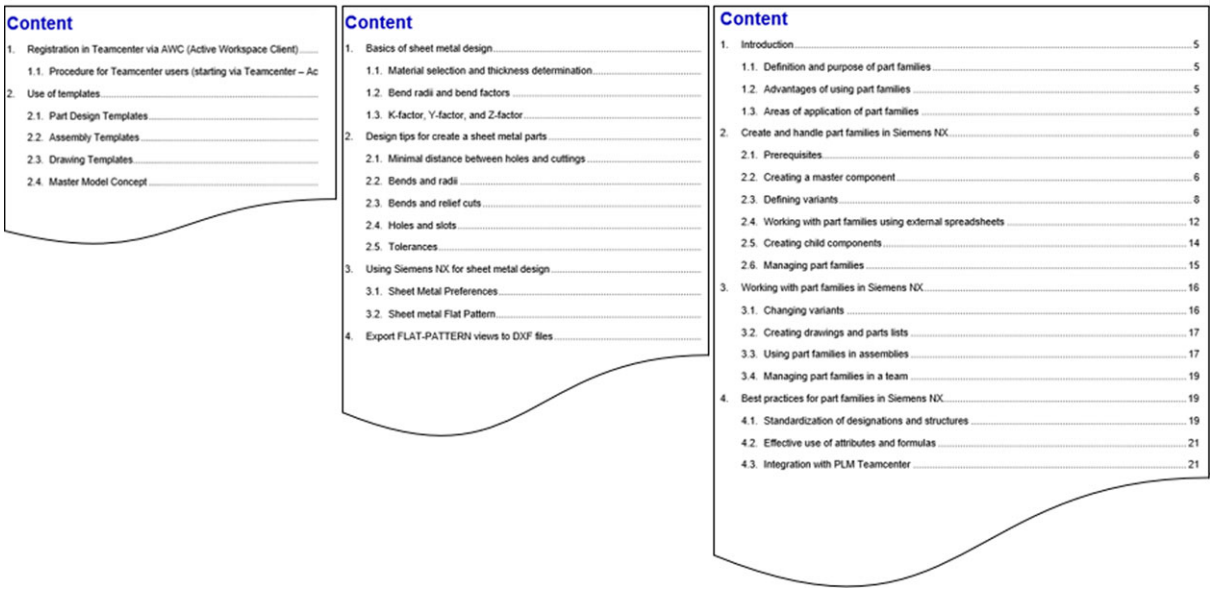


Figure 3. Examples of guideline structures illustrating variability in scope, length, and content

4.5. Transition to broader learning phases

Following the completion of the initial phase, the key users, who were now equipped with validated practices and a deeper understanding of procedures, were established as multipliers within their respective teams. Their role shifted from that of learners to facilitators of learning, supporting the adoption of the new systems by end users. A subsequent phase of the programme involved providing structured training sessions for the wider user base, building on the experiences and materials developed during the initial phase with the key users (Ngahane Nana et al., 2026).

The next section presents the results of this training phase, focussing on observable outcomes in terms of skill acquisition, data consistency and the development of a shared modelling culture across the organisation.

5. Result and discussion

Guideline-based training produced observable improvements in the individual learning processes and organisational coordination. This was identified through structured participants' feedback, iterative guideline revisions, and comparative reflections on previous software transitions. Key users across all sites reported accelerated familiarisation with the new CAD/PLM environment, greater modelling and data management consistency, and improved team communication. These results demonstrate how guidelines can support both learning and standardisation when used as mediating artefacts. Taken together, these observations can be grouped into a set of recurring outcome dimensions reflecting how guideline-based training shaped learning processes, work practices, and organisational coordination. As illustrated in Figure 4, guideline-based training is associated with interconnected organisational, cognitive, operational, and pedagogical outcomes, which together characterise the approach's benefits.

5.1. Cognitive and organisational outcomes

From a cognitive perspective, the structured format of the guidelines minimised the need for trial-and-error learning and improved understanding of procedural logic. As key users applied each guideline to real projects, they internalised design conventions and system interactions more effectively, benefitting from learning by doing. The guidelines also acted as cognitive scaffolds, reducing memory load and enabling users to concentrate on problem-solving instead of recalling interface sequences. This fostered greater autonomy and confidence among participants.

At an organisational level, the guidelines harmonised modelling practices across departments and sites, creating a shared knowledge base and facilitating collaboration between specialists in different locations. Validated procedures will enable new employees or contractors to integrate more quickly, thereby supporting knowledge transfer and digital continuity.

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Figure 4. Summary of learning outcomes from the guideline-based training

These cognitive effects were identified through self-reports from participants during review sessions, as well as through a decreasing number of clarification requests as guideline iterations progressed. Several users explicitly reported a reduced reliance on trial and error, as well as an increased confidence in explaining procedures to others.

5.2. Operational benefits and limitations

Operationally, clearer procedures reduced rework and inconsistencies within the PLM system, and predefined workflows shortened design cycles. Iterative guideline updates ensured alignment with evolving practices and supported the development of sustainable expertise. Nonetheless, several challenges also emerged. Coordinating live discussions across time zones limited synchronous exchange, and differences in local working methods occasionally resulted in different interpretations of the same rules. Furthermore, some users expected the new software to replicate the functions of the old system exactly, highlighting the tension between innovation and habit. Addressing these issues required a balance between standardisation and local adaptability, which is an inherent challenge in global engineering environments.

Although precise time measurements were not systematically recorded, multiple participants reported that the adaptation phase was noticeably shorter than earlier transitions, particularly during the initial modelling and validation stages. These comparative assessments were based on users' experience of implementing similar software changes within the organisation.

5.3. Comparative and academic insights

Compared with previous software transitions that lacked structured training, this approach significantly reduced adaptation time and disruption to operations for key users. The availability of written references that could be updated proved critical for sustaining learning beyond the initial rollout. The collaborative development of guidelines also fostered organisational learning by making implicit rules explicit and highlighting inconsistencies in existing practices.

From an educational perspective, the study has several implications. Firstly, learning should shift from tool-based instruction towards process-oriented learning to help learners understand the importance and application of design procedures. Secondly, problem-based scenarios that mirror real engineering contexts can promote procedural understanding and reflective practice. Thirdly, involving learners in the

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co-creation or adaptation of guidelines can enhance critical thinking and ownership of standards. Finally, integrating guideline-based frameworks into CAD/PLM curricula could help to bridge the gap between academic exercises and professional design workflows (Boud & Solomon, 2003; Knowles et al., 2020; Tynjälä, 2008).

While most of the feedback was positive, some contributors expressed concerns about the extra work involved in testing the guidelines, especially when facing tight project deadlines.

6. Conclusion and outlook

This study demonstrates that guideline-based training can effectively bridge the gap between technological change and human learning during a Computer-Aided Design/Product Lifecycle Management (CAD/PLM) transition. Grounding instruction in authentic engineering workflows promoted procedural understanding, reflective practice, and sustainable competence development. The guidelines simultaneously served as learning artefacts and organisational standards, enabling key users to learn through their daily work while ensuring consistency across sites.

The study contributes to current discussions in design education and industrial learning by demonstrating that:

- Workflow-integrated guidelines accelerate the acquisition of procedural and conceptual skills, reducing dependence on trial-and-error learning.
- Participatory creation and iterative refinement of guidelines strengthen organisational learning by transforming tacit knowledge into shared practice.
- Guideline-based frameworks promote collaboration across distributed teams and encourage coherence in global engineering environments.

From an educational perspective, the findings suggest that integrating guideline-based approaches into Computer-Aided Design (CAD)/Product Lifecycle Management (PLM) courses can help students develop the adaptive, process-oriented competencies required in modern design practice. Creating and testing guidelines in an academic setting could encourage critical thinking, collaborative knowledge-building, and a better grasp of professional modelling workflows.

This learning model can be scaled up to cover other digital engineering transformations, such as the integration of simulation environments, data-centric platforms, and AI-assisted design tools, where structured, practice-oriented learning is required to align human expertise with evolving technologies. Future research projects could explore how digital platforms, blended learning formats and AI-driven assistants could support adaptive guideline systems that evolve alongside users' competencies and organisational requirements. This could be applied to university–industry collaboration settings, for example.

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