

# Blended Learning Strategies for Skill Retention in Facility Management

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## Abstract

Education and training in facility management (FM) are increasingly adopting blended learning because of the profession's growing digital competence requirements, the importance of sustainable decision-making, troubleshooting, and safe operation. The present review article explores the potential of blended learning strategies that can be used to facilitate skill acquisition, skill retention, and transfer of learning in FM training and professional development. Literature from the fields of vocational education, technology-enhanced learning, simulation-based training, skill decay research and FM competency development is drawn upon. The review suggests that blended learning is well suited to FM when online content is purposefully connected to operational activities, face-to-face workshop sessions are used to reinforce learning, simulated learning experiences are applied to operational activities and formative feedback is provided, and spaced refresher sessions are incorporated. The body of evidence from related vocational and safety-critical disciplines suggests that retrieval practice, distributed practice, authentic simulation and learning analytics could be used to help maintain long-term competence, although evidence in the context of FM is limited. The paper suggests a conceptual design of retention-oriented blended FM training and lays out future research needs such as the evaluation of retention effects, instructional design for competency, refresher scheduling, and evaluation of effects on workplace transfer.

## Keywords

Blended Learning, Facility Management, Skill Retention, Distributed Practice, Learning Analytics, Professional Training, Engagement, Competency-Based Education

## 1. Introduction

Blended learning has become a prominent instructional approach in technical and

vocational education by integrating face-to-face instruction with technology-supported activities to facilitate flexible, practice-focused skill development [1]-[3]. In professional settings, blended designs are used to connect theoretical knowledge with practical activities and work-related simulations, allowing learners to move repeatedly between conceptual knowledge and real-world performance settings [1] [4]. Applied competencies are essential in facility management (FM), which integrates building technology, operations, sustainability, and user experience. Digitalisation, sustainability demands, and increasingly complex building systems are reshaping the profession, creating a long-term need for technicians and managers who can operate, maintain, and optimise facility assets over long life cycles [5].

In this larger context, FM has a vital role in meeting sustainable development objectives, particularly in energy conservation, carbon-emission reduction, and resilient building operations [5]. Modern FM practice combines business management, building engineering, environmental performance, and user well-being, while responding to the rapid development of smart building technologies, building information modelling (BIM), and data-driven maintenance approaches [5]. These changes increase the need for FM staff to learn complex psychomotor and cognitive tasks, such as building management systems, analysing performance data, and executing emergency procedures, and to maintain these skills over the long term despite infrequent practice. FM-based training models must therefore support not only the acquisition of initial skills, but also the retention and transfer of skills to dynamic operational conditions.

Studies in technical and vocational education and training (TVET) indicate that blended learning can support flexibility, customisation of learning processes, and access to quality learning materials in skill-based programmes [3]. The vocational and professional education literature notes that carefully designed blended environments, including structured online modules, simulations, and guided on-site practice, are linked to better learning outcomes and learner satisfaction when interaction, scaffolding, and alignment with workplace tasks are considered [4]. Research at vocational colleges also shows that blended learning has the potential to enhance attendance, participation, and engagement in practice-based subject areas, especially where activities are closely linked to job-relevant competencies [6]. Such results place blended learning as a promising method in FM education and in-service training where students frequently juggle work with upskilling requirements and must have the chance to engage in repeated and spaced learning.

Simultaneously, evidence on skill retention in safety-critical and high-risk areas indicates that there are significant issues with retaining competence over the long term. Surveys of multi-day training programmes across safety-critical settings (healthcare, military, and offshore) indicate that complex procedural and psychomotor skills can quickly deteriorate in the absence of regular practice and that the quality of initial training, availability of refresher practice, and task difficulty heavily determine retention [7]. A systematic review of competence retention in safety-critical professions also states that competence tends to decline over time, and

long-term performance is shaped by the nature of initial training design, frequency and format of refresher training, and the characteristics of individual learners [8]. These findings are highly relevant to FM, where staff members are expected to respond effectively to low-frequency but high-consequence events such as system breakdowns, fires, or severe weather-related impacts on premises.

Although there has been increasing interest in blended learning and competence retention, there are several important gaps at the intersection of these research streams. First, research on blended learning in vocational education has grown rapidly although most evidence concerns general TVET programmes, higher education courses, or discipline-specific contexts outside FM, with limited consideration of the specific knowledge, skills, and multi-stakeholder environment of FM roles [2]. Second, numerous studies on blended learning focus on short-term results, including immediate test scores, satisfaction, or engagement rather than long-term assessments of skill retention, recertification performance, or on-the-job competence in real facility settings [4]. Third, although competence retention studies involving reviews are valuable in understanding skill decay and refresher training, such studies seldom investigate how blended instructional strategies (e.g. spaced online refreshers associated with on-site drills or simulation-based practice integrated into work schedules) can be tailored to FM tasks [8]. Consequently, little consolidated evidence of how blended learning can be purposefully structured to enhance long-term skill retention across the variety of technical, managerial, and safety-critical roles that define FM practice is available.

This review aims to fill these gaps by summarizing the literature on blended learning, vocational and professional education, skill retention, simulation-based learning and changing competency needs in facility management. The paper does not report a new intervention trial; rather, it develops a literature-informed conceptual framework for designing retention-oriented blended learning in FM contexts. The following sections review the existing evidence, explain the potential mechanisms by which blended learning can contribute to long-term skill learning and discuss implications for the design of blended learning for FM training and future research agendas for empirical evaluation.

In this review, skill retention refers to the maintenance of knowledge and procedural competence after a delay following initial instruction. Transfer refers to the application of learned FM knowledge or procedures to authentic or simulated workplace tasks beyond the original learning activity. Engagement refers to behavioural and cognitive participation in learning activities, including attendance, interaction with learning materials, completion of practice tasks, and active involvement in problem-solving. Self-regulation refers to learners' capacity to plan, monitor, and adjust their learning strategies across face-to-face, online, and practice-based components. Self-efficacy refers to learners' perceived confidence in performing FM-related technical or procedural tasks. Because this article is a review, these constructs are treated as conceptual outcomes reported across the literature rather than as primary outcomes measured in a new dataset.

## 2. Literature Review

To contextualise the review, prior studies on blended and technology-enhanced learning in vocational and professional environments are reviewed to show that specific design elements may influence learning outcomes, self-efficacy, and higher-order skills [9]-[12]. Evidence on immersive, practice-based learning is complemented by research on virtual reality (VR), simulation, and safety-critical training [13]-[16]. Recent studies comparing face-to-face, online, and blended modalities and meta-analyses of VR-based safety training indicate continuing uncertainty about which modalities best support long-term knowledge retention and procedural competence in adult education and workplace training environments [17] [18]. **Table 1** provides a summary of selected studies relevant to blended learning, simulation-based training, and skill retention.

## 3. Methodology

This article adopts a narrative, review-based conceptual synthesis approach to examine how blended learning strategies may support skill retention in facility management education and professional training. The review is based on the literature related to blended learning, vocational education, simulation-based training, skill decay, retrieval practice, distributed practice and facility management competency development. It was informed by skill-retention theory, which holds that skill acquisition and retention can be understood across cognitive, associative, and autonomous stages [19], and by the meta-analytical evidence that skill loss can vary substantially during periods of non-use, and that task characteristics, overlearning and refresher-intervention design influence skill retention [20]-[22]. This conceptual background is particularly relevant, as facility management operations tend to be both cognitively demanding and operationally critical and therefore vulnerable to degradation unless they are periodically revisited or refreshed.

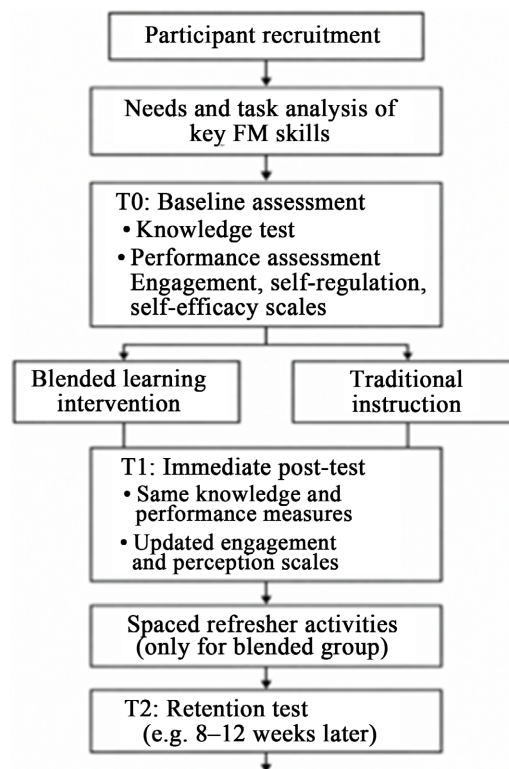
The methodological rationale is based on empirical evidence that the instructional design, practice conditions and refresher activities should be aligned with the cognitive processes operating at different stages of learning to support long-term performance [19]. Past studies on skill decay have shown that the length of the non-use interval, achieved overlearning, and task complexity are significant predictors of retention and that more complex tasks are more susceptible to decay [20]. Experimental studies carried out in simulated process-control environments also indicated that certain refresher interventions (e.g., practice-based and test-based refreshers) support knowledge and skill retention in different ways, and that refresher interventions relying on effortful retrieval may substantially reduce the initial decline [21]. The relevance of integrating task-analysed skill training with brief, timely refresher training to maintain competence in non-routine and safety-critical situations was also supported by a scoping review of high-risk and automated industry skill decay [22]. The conceptual synthesis also drew on blended learning studies that revealed that teaching presence and social presence influence student engagement, self-regulation, and perceived learning [23]-[25].

**Table 1.** Summary of selected studies informing blended learning, simulation-based training, and skill retention.

Focus	Key findings and conclusions	Ref
Blended learning models and outcomes for vocational students	This review maps dominant blended learning models in vocational education and reports generally positive effects on cognitive learning outcomes, while noting limited attention to practical skill transfer and long-term retention.	[9]
Synchronous–asynchronous blended learning and learner outcomes	Shows that combining synchronous and asynchronous components in blended courses improve self-efficacy and learning achievement compared with more traditional formats, provided that alignment between online and classroom activities is explicit.	[10]
STEAM-based blended learning and higher-order thinking	Demonstrates that STEAM-oriented blended learning significantly enhances critical and creative thinking skills, suggesting that structured integration of online and face-to-face inquiry tasks can support complex problem-solving relevant to technical domains.	[11]
Engaging online/blended models for vocational learners	Identifies platform, content, and strategy configurations that vocational students perceive as engaging and manageable (short videos, concise readings, balanced synchronous-asynchronous time), highlighting design elements that may support sustained participation and skill practice.	[12]
VR training format and skill retention	Compares desktop and head-mounted-display VR training and shows that both formats can support short-term performance gains, with indications that higher immersion may lead to better retention for certain procedural tasks, though effects vary by task complexity.	[13]
Effectiveness of VR training across domains	Systematic review indicating that VR training generally yields equal or better performance than non-VR approaches, particularly for complex psychomotor and safety-relevant tasks, while also emphasizing the need for more long-term retention measures.	[14]
VR safety training and knowledge retention	Meta-analysis shows that VR-based safety training outperforms traditional methods for both knowledge acquisition and retention and highlights a lack of consistent long-term follow-up in existing studies.	[15]
VR feature design for professional skill training	Systematic review mapping how technical and experiential VR features (immersion, haptics, feedback) relate to different categories of skill outcomes; concludes that most implementations prioritize skill-based outcomes and often rely on subjective assessment, with limited objective retention data.	[16]
Modality and knowledge retention in adult courses	Empirical comparison of adult English courses offered face-to-face, online, and in blended mode, indicating that well-designed online or blended formats achieve at least comparable long-term knowledge retention to classroom-only courses, when course structure and assessment are aligned.	[17]
Systematic review of VR for safety-relevant training	Review of VR applications in safety-relevant training contexts reporting generally positive effects on hazard perception, procedural performance, and engagement, while underscoring heterogeneity in study design and a need for robust retention and transfer measures.	[18]

The conceptual framework further draws on blended learning studies showing that teaching presence, social presence, perceived learning, engagement, and self-regulation are important mechanisms in technology-supported learning environments [23]-[25]. More robust behavioural and cognitive engagement, and positive downstream performance and persistence are more likely in blended learning environments that strategically incorporate engagement, instructional support, and pedagogical presence [23] [24]. Structural equation modelling research in blended

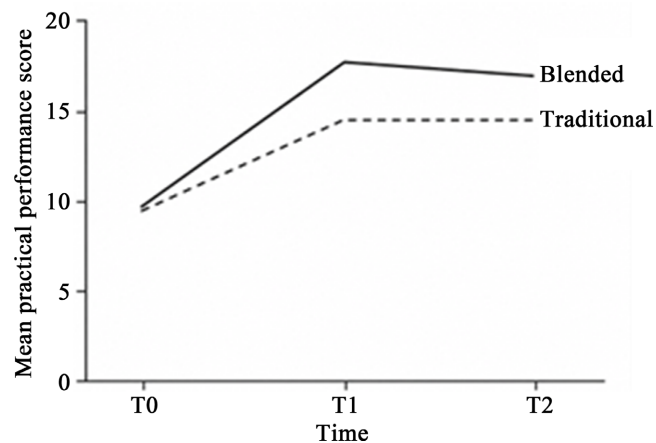
learning also indicates that metacognitive self-regulation is a mediator between features of instructional design and perceived learning outcomes [25] [26]. These findings support a conceptual framework in which engagement, self-regulation, perceived relevance, and self-efficacy are treated as mechanisms that may explain how blended learning design features influence skill acquisition, retention, and transfer [19] [27]. Adaptations of the Kirkpatrick model are relevant to future evaluation of blended FM training because they provide a structure for examining learner reaction, learning, behavioural transfer, and possible operational outcomes [28]. Because this article is a conceptual review rather than an empirical trial, participant recruitment, institutional sampling, enrolment, and group allocation are not applicable. The population of interest is defined conceptually as FM learners and practitioners, including students, technicians, supervisors, and managers who require recurring competence in building systems, safety procedures, energy management, maintenance planning, and emergency response. **Figure 1** presents the proposed conceptual framework.



**Figure 1.** Proposed future evaluation framework for retention-oriented blended FM training.

The proposed theoretical model integrates skill-retention theory [19]-[22] and the blended learning engagement and self-regulation models [23]-[26]. The model assumes that intermediate psychological and behavioural states would be influenced by specific blended-learning design features which in turn would influence immediate performance and subsequent retention in facility-management tasks. Research indicates teaching presence and structured interaction support engage-

ment and self-regulation [23]-[26], while skill-retention literature indicates that practice distribution, refresher design, and task characteristics influence decay over time [22]. Accordingly, the model hypothesized that design features such as realistic simulations, spaced practice, feedback and interaction would be the determinants of learner engagement and self-regulation; that engagement and self-regulation would mediate the relationship between design features and short-term learning outcomes in terms of knowledge and procedural skills, and that short-term outcomes and refresher exposure would influence retention and perceived transfer to workplace tasks. **Figure 2** presents a hypothetical performance retention trajectory for blended and traditional instruction [23]-[26].



**Figure 2.** Hypothetical performance-retention trajectory for blended and traditional instruction.

As this article is a review and conceptual synthesis, no participants were recruited and no allocation to intervention or comparison groups was conducted. Evidence was instead synthesized from published studies on blended learning, vocational education, technology-enhanced training, simulation-based learning, skill decay, refresher training, and FM competency development. Where empirical studies from adjacent fields are discussed, their designs are interpreted as supporting evidence rather than as primary data generated in the present article.

Based on the reviewed literature, a retention-oriented blended FM training model should include five interrelated components: face-to-face workshops for core concepts and procedural demonstration; asynchronous microlearning modules for flexible review of building systems, safety rules, maintenance procedures, and sustainability practices; simulation-based activities for troubleshooting and emergency-response scenarios; supervised workplace or lab-based practice for procedural transfer; and spaced refresher activities after initial training. In a future empirical trial, these components should be reported in replicable detail, including number of sessions, duration, learning objectives, instructional materials, simulation scenarios, refresher frequency, and total instructional time. Comparable instructional time would be necessary in both blended and comparison conditions to compare the effect of delivery design rather than training exposure [20]-[22].

Any classroom-only comparison should be matched as closely as possible in terms of the content emphasis and instructional time to allow for a clearer determination of the effect of the blended design in the future, when a comparison is used.

Since this is a review article, there was no new knowledge test, performance checklist, rater-training protocol or survey scale administered. Instead, the literature reviewed was examined in terms of the outcome categories related to the context of FM training: conceptual knowledge, procedural performance, delayed retention, transfer to authentic or simulated working tasks, self-regulation and learner engagement, self-efficacy. Analysis of studies was conducted by comparing outcomes that were measured using objective tests, performance tasks, simulation scores, checklist-based observation and self-report scales or qualitative learner accounts. Studies were considered methodologically stronger when they used clear scoring criteria, delayed assessment, objective measures of performance, evidence of reliability, or triangulation between quantitative and qualitative data.

No primary quantitative data were analysed; therefore, statistical procedures such as SEM, path analysis, repeated-measures ANOVA, ANCOVA, or correlation analysis were not conducted. The literature reviewed was nevertheless synthesized narratively to examine the possibilities for using blended learning design features and retrieval practice, distributed practice, simulation-based training, learner engagement and refresher activities for skill retention in the field of facility management. Therefore, **Figure 2** is given as a conceptual model for further empirical testing and not as a statistically tested model.

#### **4. Literature Synthesis and Discussion**

This section does not reflect the outcome of an intervention study but is the result of a synthesis of evidence based on the reviewed literature. The general mechanisms through which blended learning might promote skill retention are explored, with the following mechanisms highlighted: integration of online and face-to-face learning, retrieval practice, distributed practice, simulation-based learning, engagement of learners, self-regulation and refresher training [29]-[35].

Research on vocational and professional education has shown that blended learning is more effective when there is a clear and intentional connection between the online and face-to-face components than when they are disjointed. Face-to-face sessions are essential for demonstration, supervised practice, feedback, and discussion, whereas online modules provide opportunities for preparatory learning, review, and flexible repetition of key concepts. For FM training, online learning should complement hands-on practice by preparing learners to engage more effectively with building systems, maintenance tasks, safety procedures, and troubleshooting scenarios.

The literature on skill retention suggests that if a skill is complex or infrequently performed, competence may decline after the skill is not reinforced over time. This is particularly important for facility management, as the situations may be related to emergency response, system shutdown, alarm interpretation, safety in-

spections, and fault diagnosis, all of which may occur intermittently or under emergency conditions. Therefore, retrieval-based quizzing, spaced rehearsal, scenario-based activities and periodic simulation should be included in blended FM training to promote retention of knowledge and procedural competence.

Evidence from simulation-based and technology-enhanced training studies also indicates that authentic practice environments have the potential to enhance procedural competence and confidence and facilitate transfer, especially when feedback and repeated practice opportunities are provided. FM simulations may include HVAC fault diagnosis, BMS notifications, energy-performance troubleshooting, fire-safety procedures, and preventive-maintenance scheduling. However, as found in the literature reviewed, there are numerous studies that rely on short-term outcomes, self-report, or short follow-up. FM-specific longitudinal studies are needed to assess the long-term effectiveness of blended learning with a greater focus on the workplace competencies.

There are three general interpretations of the reviewed studies. First, blended learning is likely to be more effective in improving learning when online and face-to-face learning are not perceived as separate delivery methods but are integrated into a coherent instructional sequence with clearly stated learning goals, feedback, and guided learning. Second, retrieval practice and distributed practice provide a strong theoretical basis for designing refresher activities that may reduce skill decay over time. Third, simulation and scenario-based learning are especially relevant to FM because they allow learners to practise low-frequency but high-consequence tasks, such as system faults, alarm response, emergency shutdown, and safety procedures, in controlled environments. However, because direct FM-specific longitudinal evidence remains limited, these conclusions should be interpreted as a literature-based rationale rather than as findings from a new intervention trial.

The synthesis suggests that blended and other technology-supported designs may strengthen FM skill retention when they combine structured online learning, face-to-face practice, retrieval-based review, distributed practice, and authentic simulation. However, because direct FM-specific longitudinal evidence remains limited, these conclusions should be interpreted as a conceptual and literature-based synthesis rather than as findings from a new intervention trial.

More recent meta-analytic and quasi-experimental research in mathematics and science education has also shown that blended and technology-supported designs can be effective in improving achievement or retention over time when interaction and practice are well designed [33]-[35]. Although these studies were conducted primarily in an educational context, retrieval practice, spacing, and active engagement principles can be theoretically applied to vocational and facility-management training. Overall, these findings indicate that a blended learning approach involving retrieval practice, distributed practice and authentic simulation tasks may support short- and long-term FM skill outcomes potentially more effectively than face-to-face instruction alone, although this claim requires direct

FM-specific testing [29]-[35].

## 5. Future Directions

Future research should include large-scale, multi-institutional trials to test the effectiveness of different blended learning configurations for long-term skill retention in facility management (FM). Empirical research shows that distributed practice across multiple sessions is more effective in supporting durable memory than massed or single-block training [30]. Future studies could systematically vary refresher frequency, duration, format, and spacing (e.g., microlearning, simulation-based exercises) to determine the most effective spacing schedules for FM tasks.

Future studies should align blended FM training designs with established competency frameworks. FM competency development should reflect operational, sustainability, safety, and management demands identified in the FM literature [5]. Studies of FM education also stress the need for structured curricula and conceptual clarity in FM education [5]. Future research could map specific blended design features (authentic simulations or building-systems case analyses) onto these competency areas and determine their impact on retention and transfer to the workplace.

Another promising direction is the use of learning analytics (LA). Prior studies on blended learning and engagement suggest that digital learning environments can support monitoring of learner participation and targeted instructional support [23]-[26]. Engagement-based conceptual models offer holistic frameworks for describing the cognitive and behavioural processes that determine performance in blended environments [23]-[26]. Future FM studies could use LA dashboards and engagement indicators to identify declining performance trends and trigger timely, adaptive refresher activities.

Finally, contextual variables such as institutional infrastructure, workforce diversity, and regional FM practices must be considered. Conceptual FM models indicate that institutional mission and regulatory environment influence FM operations as well as training requirements [5]. Future research could explore the suitability of blended FM training in a variety of organisational settings and examine equity and accessibility for different learner groups, including contract technicians, early-career workers and non-traditional learners.

## 6. Conclusions

The reviewed literature indicates that blended learning has strong conceptual relevance for FM education when it is designed around distributed practice, authentic simulation, formative feedback, and periodic refresher activities. This pattern is consistent with research showing that distributed practice supports durable retention, and with studies reporting that engagement-oriented blended learning designs can improve learning outcomes when supported by appropriate instructional design.

Retention-oriented instructional design, combined with competency-based

training models, offers a systematic approach to facilitating professional learning in an industry where technology, sustainability requirements, and data-driven processes have increased operational complexity. Integrating learning analytics may also offer additional opportunities in the customisation of refresher activities and monitoring the learning process.

Overall, the synthesis suggests that blended learning can support sustainable, job-relevant skills in FM, provided that future research refines design parameters, evaluates its usefulness in institutional settings, and incorporates adaptive learner-support features.

## Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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