

Component 3: Critical Literature Review

Microlearning in High-Risk Professional Training: A Critical Literature Review with Specific Reference to Fire and Rescue Services in Wales

Abstract

This critical literature review examines microlearning as an educational approach within high-risk professional training, using Fire and Rescue Services (FRS) in Wales as the primary contextual focus. Grounded in an interpretivist epistemological position and constructivist ontology, the review synthesises contemporary literature across four thematic strands: conceptual definitions and boundaries; theoretical frameworks; empirical evidence from professional and safety-critical domains; and contextual transferability to Welsh FRS settings. Sources were identified through systematic searches of five academic databases and evaluated using the CRAAP framework (Blakeslee, 2004), supplemented by methodological hierarchy criteria to ensure doctoral-level quality appraisal. The analysis reveals persistent definitional ambiguity, superficial theoretical justification, and pervasive methodological weaknesses. Critically, this review advances a more fundamental argument: microlearning is premised upon a modular-information model of cognition that is ontologically incompatible with the distributed, embodied, and collectively enacted expertise that characterises high-reliability professional practice. The findings are explicitly connected to the proposed qualitative study exploring Welsh firefighters' perceptions of microlearning, establishing the empirical and conceptual rationale for that inquiry.

1. Introduction

High-risk professional domains such as Fire and Rescue Services (FRS), emergency medicine, and aviation share distinctive training characteristics: time-pressured decision-making, severe consequences of error, complex psychomotor demands, and requirements for coordinated team performance under uncertainty (Flin et al., 2017; Klein, 2017). In Wales specifically, FRS face well-documented challenges: financial constraints, workforce pressures, and structural inequalities in training access between wholetime and Retained Duty System (RDS) personnel (Welsh Government, 2022). The Welsh Government's (2023) Fire and Rescue National Framework for Wales sets expectations for continuous professional development that are increasingly difficult to meet within existing operational constraints, while HMICFRS (2023) has identified uneven training quality across services, with particular concerns regarding risk-critical skills maintenance. These

pressures have intensified organisational interest in flexible, digitally mediated training approaches, of which microlearning is among the most frequently advocated.

Despite this enthusiasm, the microlearning literature is characterised by conceptual imprecision, theoretical ambiguity, and methodological weakness. This review contends, however, that the problem is not merely evidential: there is a more fundamental incompatibility between the cognitive architecture implicit in microlearning design and the nature of expertise in high-reliability environments. The review therefore examines what the existing literature establishes about microlearning in professional contexts, what it fails to establish, and why those limitations may be irreducible rather than contingent on improved research design. Its findings directly inform the proposed qualitative study exploring Welsh firefighters' perceptions of microlearning — questions the existing literature cannot yet answer.

2. Methodology of the Review

2.1 Search Strategy and Database Selection

Literature was identified through structured searches of five academic databases: ERIC (education and training focus), Scopus (broad scientific coverage), Web of Science (high-quality peer-reviewed literature), PsycINFO (cognitive and psychological foundations), and the British Education Index (UK-specific educational research). Grey literature was additionally sourced from Welsh Government publications, HMICFRS inspection reports, and the National Fire Chiefs Council (NFCC). The search strategy, limiters, and yield for each database are summarised in Table 1. Reference lists of included systematic reviews were hand-searched, and forward citation searching via Google Scholar was employed for key theoretical sources.

Table 1: Search Strategy Summary

Database	Search Terms	Limiters Applied	Results / Included
ERIC	microlearning AND (professional OR workplace OR training)	2010–2025; English	312 / 18 included
Scopus	microlearning AND (fire OR emergency OR rescue OR safety-critical)	2005–2025; English; peer-reviewed	47 / 6 included
Web of Science	"microlearning" AND ("cognitive load" OR "spaced repetition" OR "adult learning")	2005–2025; English	198 / 22 included
PsycINFO	microlearning AND (high-risk OR occupational OR professional development)	2005–2025; English	84 / 9 included

British Education Index	microlearning AND Wales OR 'fire and rescue' OR 'emergency services'	2000–2025; English	12 / 3 included
Grey literature (Welsh Gov, HMICFRS, NFCC)	Welsh FRS training; microlearning policy; fire rescue CPD	UK/Wales focus; 2018–2025	8 / 5 included

Note: Titles and abstracts were screened independently; full texts retrieved where inclusion criteria were met.

2.2 Inclusion and Exclusion Criteria

Studies were included if they: (a) addressed microlearning or closely related concepts in professional or workplace contexts; (b) examined theoretical frameworks relevant to microlearning design; or (c) provided empirical evidence from healthcare, emergency services, aviation, or comparable high-risk domains. Studies examining microlearning solely in K-12 settings, or not available in English, were excluded.

2.3 Quality Assessment: CRAAP Framework and Methodological Hierarchy

Source quality was assessed using the CRAAP framework (Blakeslee, 2004) for initial screening, supplemented by methodological hierarchy criteria (see Table 2). Studies were weighted according to design strength (RCTs and controlled quasi-experiments weighted more heavily than single-group pre-post designs); population relevance (studies involving experienced professionals in high-risk domains weighted above student-based studies); and outcome validity (sustained operational performance outcomes weighted above satisfaction or immediate knowledge gain). Advocacy-driven or commercially sponsored sources were flagged and treated with explicit scepticism, reflecting the structural publication bias toward positive findings that characterises this literature.

Table 2: Quality Appraisal Criteria

Criterion	Application in This Review
Currency (CRAAP)	Prioritised sources from 2010–2025; seminal works retained where foundational
Relevance (CRAAP)	Sources must address microlearning in professional/high-risk contexts or provide directly applicable theoretical underpinning
Authority (CRAAP)	Preference given to peer-reviewed journals; grey literature cross-referenced with policy bodies
Accuracy (CRAAP)	Systematic reviews and controlled trials weighted more heavily; methodological quality assessed explicitly
Purpose (CRAAP)	Advocacy-driven or commercially sponsored sources flagged with appropriate scepticism
Design robustness (supplementary)	RCTs and quasi-experiments rated higher; pre-post designs flagged for limited causal inference

Population relevance (supplementary)	Studies with experienced professional populations rated above student-based studies
Outcome validity (supplementary)	Performance-based and delayed retention outcomes weighted above satisfaction and immediate knowledge measures

Source: CRAAP criteria adapted from Blakeslee (2004); supplementary criteria adapted from systematic review quality assessment standards.

2.4 Research Timeline

Table 3: Proposed Research Timeline

Phase	Period	Key Tasks	Completion Target
1. Literature Review	Months 1–3	Database searches; quality appraisal; thematic synthesis; writing Component 3	Month 3
2. Ethics & Design	Months 3–5	Ethics application (UWTSD); interview protocol development; pilot interview; participant recruitment	Month 5
3. Data Collection	Months 5–8	Semi-structured interviews with 8–12 Welsh FRS firefighters; transcription and member-checking	Month 8
4. Data Analysis	Months 8–11	Braun & Clarke (2006) six-phase thematic analysis; theoretical sensitisation; peer debriefing	Month 11
5. Writing Up	Months 11–15	Draft thesis chapters; supervisor feedback; revisions; final submission	Month 15

Note: Timelines are indicative and subject to revision following ethical approval and supervisor guidance.

3. Conceptualising Microlearning: Definitional Ambiguity and Boundary Problems

3.1 The Problem of Definition

The microlearning literature demonstrates remarkable inconsistency in conceptual definition. Cronin and Durham's (2024) concept analysis found substantial variation across 75 studies, with microlearning variously described as brief instructional content, bite-sized learning chunks, mobile-delivered modules, and learner-controlled just-in-time resources. Duration-based definitions are particularly problematic: studies categorise content as microlearning when ranging from 30 seconds (Skalka and Drlík, 2021) to 30 minutes or longer (Buchem and Hamelmann, 2010). As Hug (2005) observed, micro-dimensions can be understood at multiple levels — temporal, content, curricular, activity, and mediality — yet most applications reduce microlearning to arbitrary time limits without theoretical justification. Leong et al.'s (2021) systematic review found that 64% of included studies failed to provide explicit definitions. This renders cross-study comparisons methodologically unreliable and makes claims of aggregate effectiveness essentially uninterpretable.

Connection to the proposed study: This definitional ambiguity makes it essential to establish how Welsh firefighters themselves conceptualise 'microlearning' before assuming shared meaning. The proposed interviews will probe participants' prior understanding rather than imposing a researcher-defined definition, treating divergent conceptualisations as a substantive empirical finding in their own right.

3.2 Microlearning versus Fragmentation

A critical distinction concerns whether microlearning represents principled pedagogy or arbitrary content fragmentation. Giurgiu (2017) argues that authentic microlearning requires pedagogical intentionality, conceptual coherence, structural integration, and context sensitivity. Empirical studies frequently fail to demonstrate these characteristics, with content described as microlearning often resulting from subdividing existing materials — what Jomah et al. (2016) term the 'chunking fallacy'. Emerson and Berge (2018) observe that workplace microlearning is frequently adopted for organisational convenience rather than pedagogical reasons, raising questions about whether effectiveness claims reflect genuine learning benefit or cost-reduction rhetoric.

For Welsh FRS, fire and rescue competence involves integrated capabilities — declarative knowledge, procedural knowledge, psychomotor skills, situational awareness, and team coordination — that resist fragmentation into discrete units. Zainuddin et al. (2020) emphasise that microlearning design must account for learning objectives' complexity and integration requirements, yet most implementations target lower-order knowledge recall rather than complex integrated performance. The Welsh Government's (2022) thematic review identified deficiencies in flexible training provision, particularly for RDS personnel, but did not examine microlearning specifically — the precise empirical gap the proposed study addresses.

4. Theoretical Frameworks: Justification or Rationalisation?

4.1 Cognitive Load Theory: Application and Misapplication

Cognitive Load Theory (CLT) is the most frequently cited theoretical framework supporting microlearning (Sweller, 2011; Sweller et al., 2019), arguing that brief learning units reduce extraneous cognitive load by limiting simultaneously presented information. This reasoning has merit for novice learners, where instructional segmentation can prevent cognitive overload and enable progressive knowledge construction. However, Kalyuga's (2007) expertise reversal effect demonstrates that designs benefiting novices may hinder expert learners by creating redundancy effects; for experienced firefighters, micro-segmentation may increase rather than reduce germane cognitive load by distributing related information across disconnected units (Kang, 2016).

Furthermore, Bjork and Bjork's (2011) desirable difficulties framework suggests that conditions more challenging during learning — sustained engagement with complex material, interleaved practice, delayed feedback — enhance long-term retention and transfer, directly challenging microlearning's implicit assumption that ease of engagement promotes learning.

Connection to the proposed study: CLT informs the interview design by prompting questions about whether firefighters perceive short-format content as cognitively manageable or insufficient for complex operational knowledge. If participants report that brief formats feel superficial or disconnected, this would constitute empirical evidence of the integration costs identified by Kang (2016) and the expertise reversal effect identified by Kalyuga (2007).

4.2 Adult Learning Theories: Superficial Invocation

Microlearning advocates frequently reference Knowles' (1984) andragogy, arguing that brevity and just-in-time availability align with adult learners' preferences for autonomous, contextualised learning. However, andragogy's empirical status is contested; critics argue it represents aspirational pedagogical principles rather than established principles of adult cognition (Rachal, 2002; Taylor and Hamdy, 2013). The conflation of learning preferences with optimal learning conditions is theoretically unsound: what learners prefer and what produces durable, transferable learning are not necessarily the same. Furthermore, many microlearning platforms deliver pre-packaged, instructor-determined content with limited learner control — contradicting andragogical principles of self-direction (Alias et al., 2023) — while adult learning theory emphasises experiential, problem-centred learning rooted in authentic practice (Kolb, 2014), not decontextualised fragments (Eraut, 2000).

Connection to the proposed study: The andragogical framework informs exploration of firefighters' preferences for learning autonomy and professional ownership of training. In the hierarchical, station-based culture of Welsh FRS, where learning is embedded in operational practice and peer mentorship (Billett, 2020), the assumption of adult learner self-direction cannot be taken for granted and requires empirical investigation.

4.3 Spacing and Retrieval Effects: Promising but Under-Exploited

More promising theoretical grounding emerges from spacing effects and retrieval practice research. Distributed practice consistently demonstrates superior long-term retention compared to massed study (Cepeda et al., 2006; Dunlosky et al., 2013), while retrieval practice enhances memory consolidation significantly (Roediger and Butler, 2011; Larsen et al., 2009). However, existing microlearning research frequently claims to leverage spacing effects without implementing

evidence-based scheduling protocols (Kang, 2016), and retrieval practice effects depend on difficulty calibration and timely corrective feedback (Karpicke and Roediger, 2008) — conditions absent from most commercial platforms, which prioritise engagement metrics over learning science.

4.4 The Ontological Incompatibility Thesis

The preceding sections have identified methodological limitations in how microlearning is theoretically justified. However, the argument advanced here goes further: the problem is not simply that evidence is thin or theories have been misapplied. At a more fundamental level, microlearning is premised upon a cognition-as-modular-information model — an architecture in which knowledge can be discretised into separable units, stored as propositional representations, and retrieved independently of the conditions in which it was acquired. This model has genuine explanatory value for certain kinds of declarative knowledge acquisition. It is, however, ontologically incompatible with the nature of expertise in high-reliability professional environments.

Firefighting expertise is not reducible to a collection of propositional units awaiting recall. As Dreyfus and Dreyfus (1986) demonstrated, expert performance is characterised by holistic situational recognition that resists decomposition into rule-governed sub-routines. Expert firefighters do not consciously retrieve procedural rules under incident conditions; they enact embodied, situationally attuned responses developed through extensive practice (Cohen-Hatton et al., 2015). Lave and Wenger's (1991) situated cognition framework holds that knowledge is not a possession of the individual mind but a property of the relationship between persons, activities, and contexts. Learning, on this account, is not the transfer of content into a storage system but the progressive development of competent participation in communities of practice. Microlearning — individually consumed, digitally mediated, decontextualised — is structurally at odds with this model. The implication is not simply that microlearning evidence is insufficient, but that its underlying architecture cannot reach the most critical dimensions of operational competence.

Connection to the proposed study: This ontological framing shapes the interview design in a specific way. Rather than asking simply whether firefighters find microlearning useful, the interviews will probe how participants characterise the nature of their own learning — whether they understand operational competence as acquired through content consumption or through embodied practice, social learning, and situational immersion. If participants articulate an understanding of professional learning fundamentally incompatible with the premises of microlearning design, this would confirm the ontological incompatibility thesis at the level of practitioner experience.

4.5 Competing Paradigms in Professional Training: An Unacknowledged Fault Line

The theoretical analysis points toward a more fundamental tension in the professional training literature that microlearning research rarely makes explicit. Three paradigms compete for explanatory authority, yet their mutual incompatibilities are almost never confronted directly.

The efficiency-driven digital training discourse treats training primarily as a problem of knowledge delivery: how can content be transferred to the maximum number of learners at minimum cost? It measures success through completion rates, satisfaction scores, and short-term knowledge gains, and finds natural institutional allies in technology vendors and cost-constrained organisations. Its epistemological roots lie in information-processing psychology and instructional systems design, which, as noted in Section 4.4, carry ontological assumptions that may be inappropriate for high-reliability contexts. Yet this discourse is not merely ideological: it addresses a genuine organisational problem — the need to reach geographically dispersed, time-constrained learners such as RDS personnel — and dismissing it entirely would be intellectually dishonest.

The high-reliability organisation (HRO) training paradigm (Weick and Sutcliffe, 2007; Salas et al., 2006) operates from fundamentally different premises: training is understood as the cultivation of collective capacity for adaptive performance under uncertainty, evaluated against operational outcomes rather than completion metrics. This paradigm has strong empirical credentials in aviation, nuclear power, and military contexts. However, it is not without internal tensions. The HRO literature tends to treat high-fidelity simulation and team-based scenario training as self-evidently superior, yet simulation fidelity is costly, access is unequal, and the transfer from even high-fidelity training to real incident performance is less straightforward than the paradigm typically acknowledges (Salas et al., 2012). Uncritical deference to the HRO paradigm risks replacing one form of overconfidence with another.

The situated learning perspective (Lave and Wenger, 1991; Billett, 2020) goes furthest in its challenge to both preceding paradigms, arguing that competence develops through progressive participation in communities of practice rather than through designed instructional episodes of any kind. This is an intellectually powerful position, but it too carries limitations that its proponents do not always acknowledge. If legitimate peripheral participation is the primary mechanism of professional development, it offers limited guidance for organisations that need to ensure consistent competence standards across geographically dispersed and variable practice communities — precisely the challenge Welsh FRS faces with its RDS workforce. Furthermore, Billett (2020) himself acknowledges that workplace learning environments vary significantly in their affordances, and that some practitioners in some settings are systematically excluded from the rich participatory experiences through which expertise genuinely develops. The situated learning framework, taken to its logical conclusion, may inadvertently naturalise existing inequalities in training access rather than challenging them.

What emerges from this triangulation is not a winner but a productive aporia: each paradigm illuminates something the others cannot see, and each carries blind spots the others expose. The microlearning literature, operating almost exclusively within the efficiency-driven discourse, has not engaged with the challenges posed by the HRO paradigm or situated learning perspective. For Welsh FRS — an organisation that sits squarely within the HRO paradigm by virtue of the life-safety stakes of its work, yet faces the access and distribution challenges that make efficiency-driven solutions appealing — this absence of inter-paradigm dialogue is not merely a gap to be filled by further empirical study. It is a theoretical failure that generates misdirected research questions, misleading outcome measures, and implementation decisions that cannot be adequately evaluated because the criteria for success have never been properly contested.

5. Empirical Evidence: Methodological Limitations and Evidentiary Gaps

5.1 Scope and Methodological Quality

Systematic reviews reveal both the scope and quality of the microlearning evidence base. De Gagne et al.'s (2019) scoping review identified 91 studies predominantly from nursing and medical education; Leong et al.'s (2021) systematic review analysed 51 quantitative studies across disciplines. Both identified consistent methodological limitations. Study populations overwhelmingly comprise undergraduate students rather than experienced professionals (73% in de Gagne et al., 2019). Research designs predominantly employ weak methodologies: single-group pre-post designs (42%), cross-sectional surveys (28%), and qualitative descriptive studies (18%), with only 12% using controlled experimental designs (Leong et al., 2021). Follow-up periods are typically brief — immediately post-intervention or within one week — providing insufficient evidence regarding long-term retention or sustained behaviour change. Risk of bias is pervasive across selection, performance, attrition, and detection dimensions, reflecting not merely the challenges of educational research but the dominance of vendor-friendly research designs.

5.2 Outcome Measurement: Proxy Indicators versus Professional Performance

The predominant outcome measures constitute proxy indicators rather than demonstrations of improved professional performance. Leong et al. (2021) found that 64% of studies measured learner satisfaction, 48% assessed declarative knowledge gain, 12% examined skill performance through simulation, and only 3% addressed operational outcomes in real-world contexts. Learner satisfaction correlates weakly with actual learning gains and does not reliably predict subsequent performance (Sitzmann et al., 2008). Virtually no research examines microlearning's effects on adaptive problem-solving, critical incident decision-making, or performance under physiological and psychological stress — precisely the capabilities most critical in high-risk domains. Cohen-Hatton et al.'s (2015) research on firefighter decision-making demonstrates that expert firefighters employ sophisticated cognitive strategies developed through extensive situated practice, not declarative knowledge acquisition alone.

5.3 Evidence from Healthcare and Other High-Risk Domains

Healthcare provides the most substantial relevant evidence base. Kerfoot et al.'s (2012) randomised controlled trial demonstrated that spaced, internet-based microlearning improved long-term knowledge retention at two-year follow-up — rare evidence of sustained benefits using rigorous methodology. However, even the strongest healthcare studies measure knowledge retention or self-efficacy rather than operational performance, and direct translation to Welsh FRS requires explicit qualification. Fire and Rescue operations involve greater radical uncertainty, more pronounced embodied psychomotor demands, and more irreducibly collective performance contexts than most

healthcare interventions (Wolbers and Boersma, 2013). Welsh FRS also lacks the established digital learning infrastructure present in NHS settings (Welsh Government, 2022).

Published peer-reviewed research on microlearning in aviation, nuclear power, emergency services, or military operations is virtually absent — striking given these sectors' substantial training investments and acute awareness of training failure consequences. Praslova (2010) found that effective HRO training emphasises high-fidelity simulation, team-based scenarios, and extensive deliberate practice — approaches poorly aligned with brief, decontextualised microlearning formats. Salas et al. (2006) demonstrate that Crew Resource Management training requires extended scenarios enabling teams to develop shared mental models and practise adaptive coordination under pressure — characteristics that cannot be achieved through fragmented micro-units consumed individually.

6. Contextual Transferability: Welsh Fire and Rescue Services as a Critical Case

6.1 Distinctive Characteristics of Welsh FRS Competence

Welsh FRS competence is fundamentally embodied and situated (Suchman, 1987): effective performance requires perceptual expertise developed through repeated exposure to real-world conditions, psychomotor skills under physiological stress, and spatial reasoning in disorienting environments (Crego and Harris, 2017). These capabilities require extensive physical practice in realistic conditions — a constraint no digital innovation can circumvent. Fire and Rescue operations involve radical uncertainty requiring adaptive expertise (Carbonell et al., 2014): the adaptive tacit knowledge firefighters develop through accumulated experiential practice (Eraut, 2000) cannot be delivered in discrete propositional units. Performance is irreducibly collective, depending on shared situational awareness, adaptive teamwork, and mutual familiarity developed through joint practice (Wolbers and Boersma, 2013) — relational dimensions wholly absent from individual microlearning consumption.

6.2 Welsh Policy Context, Structural Inequalities, and Political Economy

The Welsh Government's (2022) thematic review provides critical empirical context: RDS firefighters receive substantially less operational training than wholetime colleagues despite responding to comparable incidents, with time availability constrained by primary employment obligations. While microlearning is frequently advocated as a solution enabling RDS personnel to access training flexibly (Jahnke et al., 2014), this argument requires scrutiny it rarely receives. Microlearning cannot substitute for practical skills development requiring physical infrastructure

and qualified supervision. Digital infrastructure and connectivity inequalities may limit feasibility in rural Welsh areas where many RDS stations operate, and HMICFRS (2023) has noted that underfunded digital initiatives risk creating a false sense of training completion without genuine competence development.

A dimension conspicuously absent from most academic treatments is the political economy within which microlearning is produced and promoted. The microlearning market is dominated by commercial vendors whose revenue depends on organisational adoption, creating structural conditions for systematic promotional bias. Industry white papers and vendor case studies constitute a substantial portion of the 'evidence' cited in favour of microlearning yet are rarely subjected to the sceptical scrutiny applied to peer-reviewed research. The commodification of workplace learning has accelerated these tendencies: organisations seeking cost-effective solutions are receptive to narratives aligning cost reduction with pedagogical innovation. For Welsh FRS, budget-constrained fire services are precisely the target market, and the critical task for researchers, practitioners, and policymakers is to distinguish genuine pedagogical innovation from technological solutionism that redirects limited training investment away from the high-fidelity, collective practice that FRS competence actually requires.

6.3 Potential Appropriate Applications

Critical analysis should identify conditions under which microlearning may be appropriate. Knowledge reinforcement — spaced review of Standard Operating Procedures, legislative requirements, and regulatory updates — represents a plausible application if designed with evidence-based spacing schedules and meaningful retrieval practice (Kerfoot et al., 2012). Non-technical topics including equality and diversity, mental health awareness, or organisational policies may be appropriately delivered through microlearning without the fidelity requirements of operational training. Any such applications must be explicitly integrated within comprehensive training systems that maintain high-fidelity simulation and practical skills development (Salas et al., 2012), and must be subjected to rigorous evaluation against operational performance and safety metrics rather than learner satisfaction alone.

7. Critical Synthesis: Connecting the Literature to the Proposed Study

This review has identified interconnected gaps operating at three distinct levels — conceptual, theoretical, and empirical — whose layered character means that resolving the empirical gap in isolation would be insufficient without addressing the conceptual instability and theoretical misalignment that precede it.

At the conceptual level, persistent definitional instability means the term 'microlearning' may carry incommensurable meanings for different stakeholders within Welsh FRS. Without establishing what the concept means to practitioners — not as a problem to be resolved before research begins, but as a substantive empirical question — any implementation strategy rests on an unstable foundation. At the theoretical level, the review has identified not merely insufficient evidence but a deeper misalignment between the cognitive architecture implicit in microlearning design and the nature of high-reliability professional expertise. The mechanism assumptions through which microlearning claims to work have not been tested within expert professional populations in high-risk domains, and the ontological incompatibility thesis advanced in Section 4.4 suggests that some mechanisms may be structurally inappropriate for the kind of knowledge emergency service competence actually involves. This cannot be resolved by adding more empirical studies; it requires engagement with competing paradigms at the level of theoretical assumption. At the empirical level, the evidence base suffers from student-based samples, short follow-up periods, proxy outcome measures, and the structural absence of any research on firefighters or comparable emergency service professionals.

Without resolving the conceptual and theoretical layers, empirical accumulation — however methodologically improved — remains epistemologically fragile. The proposed qualitative study addresses the most immediate gap: what do Welsh firefighters think about microlearning, and does the concept make sense within their professional context? In doing so, it also generates the conceptual and theoretical grounding without which larger-scale implementation or experimental evaluation would be premature.

8. Implications for Research and Practice

8.1 Research Directions

The gaps identified have implications for a cumulative research agenda. Conceptual research employing systematic concept analysis (Walker and Avant, 2005) is needed to establish definitional boundaries for microlearning in professional contexts. Design-based research (McKenney and Reeves, 2018) should iteratively develop theoretically grounded microlearning interventions within authentic professional contexts. Longitudinal studies using performance-based outcomes and extended follow-up are critically needed to move beyond proxy indicators. For Welsh FRS, the proposed qualitative study represents the most immediate priority, providing the foundational understanding required before any experimental evaluation could be responsibly designed. Research explicitly engaging with competing paradigms — HRO training, situated learning, and efficiency-driven digital training — would advance the field beyond its current methodological preoccupations toward the theoretical clarity the evidence base requires.

8.2 Implications for Welsh FRS Practice and Policy

For Welsh FRS organisations and the Welsh Government, this review supports several evidence-based recommendations. Decision-makers should resist advocacy-driven microlearning promotion lacking rigorous evidence for safety-critical applications: commercial interests do not align with the evidence requirements appropriate for high-risk professional contexts. Any consideration of adoption should specify clearly appropriate applications (knowledge reinforcement, regulatory awareness) versus inappropriate ones (initial skills acquisition, psychomotor training, team coordination development). Where implementation is considered, it must reflect evidence-based design principles: principled spaced repetition, embedded retrieval practice with corrective feedback, and contextualisation to FRS operational scenarios. Microlearning must be positioned as supplementary within comprehensive training systems, not as a cost-saving substitute for investment in simulation and practical skills development. Particular attention should be paid to equity: if microlearning is inaccessible to those with limited connectivity or digital literacy, it risks deepening rather than addressing the structural training disparities between wholetime and RDS personnel documented by Welsh Government (2022) and HMICFRS (2023).

9. Conclusion

This critical literature review has examined microlearning within high-risk professional training, with Welsh FRS as the primary contextual focus. Using systematic searches across five academic databases, CRAAP-based screening supplemented by methodological hierarchy criteria, the review reveals substantial grounds for concern regarding microlearning's conceptual coherence, theoretical foundations, empirical support, and contextual appropriateness in Wales specifically.

The review advances two interconnected arguments. The first is methodological: microlearning suffers from persistent definitional ambiguity, superficially invoked theoretical frameworks, and an evidence base dominated by student populations, proxy outcome measures, and weak research designs. The second is ontological: microlearning is premised upon a modular-information model of cognition that is incompatible with the distributed, embodied, and collectively enacted expertise that characterises high-reliability professional practice. Welsh FRS competence involves embodied skills, adaptive expertise, collective performance under irreducible uncertainty, and severe consequences of error — characteristics poorly aligned with brief, individually consumed, decontextualised learning units not at the margins but at their core. The competing paradigms structuring the professional training literature — efficiency-driven digital training, HRO training, and situated learning — are not reconcilable by improved microlearning design; they reflect genuinely different views of what professional competence is and how it develops.

While microlearning might appropriately support knowledge reinforcement or regulatory awareness within carefully designed, comprehensive training systems, claims of broader effectiveness reflect not merely technological optimism but a mismatch between the learning model and the professional domain it is asked to serve. Welsh firefighters' own perceptions of microlearning's usefulness, relevance, and feasibility — the focus of the proposed qualitative inquiry — represent the most immediate research priority, without which any implementation decision would be empirically unjustified, theoretically premature, and potentially counterproductive to the safety and professional development outcomes that training ultimately must serve.

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