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Designing for engagement: A systematic literature review of multimodal E-learning in TVET and post-compulsory education

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Education + Training



**Designing for Engagement: A Systematic Literature Review
of Multimodal E-learning in TVET and Post-Compulsory
Education**

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Designing for Engagement: A Systematic Literature Review of Multimodal E-learning in TVET and Post-Compulsory Education

Introduction

The accelerating digitalisation of work and learning, alongside demographic shifts worldwide, has heightened the importance of lifelong, inclusive education within Technical and Vocational Education and Training (TVET) and post-compulsory learning contexts (UNESCO, 2023; WEF, 2025). Older adults now comprise a growing share of the workforce globally, with countries such as the UK reporting increased participation due to economic insecurity and shifting retirement expectations (Office for National Statistics, 2025; ONS, 2022). Concurrently, Industry 5.0 promotes a human-centric and sustainable vision of technological innovation, challenging traditional upskilling models and requiring more adaptable, equitable learning environments (Poláková et al., 2023; Smith & Doe, 2025).

International frameworks such as the United Nations' Sustainable Development Goal 4 (United Nations, 2015), implemented through UNESCO's education agenda, and the UK's Lifetime Skills Guarantee, affirm the importance of lifelong learning for economic resilience and social inclusion (DfE, 2023b; UNESCO, 2022). In response to these ambitions, e-learning, particularly in asynchronous formats, has emerged as a low-cost, scalable learning solution. Whilst the COVID-19 pandemic accelerated the shift towards online learning, embedding it as a mainstream tool for adult and workplace education, many digital courses remain text-heavy, poorly scaffolded, or aesthetically designed rather than pedagogically grounded. A large proportion of these are lacking alignment with established instructional theories and principles that support the needs of adult learners (Perotti et al., 2025). The paradox of expanding access juxtaposed with declining design quality highlights a persistent gap between policy ambition and practice in TVET and workplace learning.

Cognitive Load Theory (CLT) provides a robust framework for structuring multimodal instructional design to optimise learning efficiency by balancing cognitive load (Sweller et al., 2011; Mayer, 2021). However, its application within adult and vocational learning contexts remains limited, with the body of scholars focusing on school or higher education populations (El-Sabagh, 2021; Fariani et al., 2022). Despite the proliferation of digital and multimodal learning approaches, few studies critically evaluate how CLT-informed design can enhance motivation, engagement, and knowledge retention among adult and workplace learners navigating asynchronous environments (Benabbes et al., 2023). This systematic review therefore responds to national and international calls (DfE, 2023a; UNESCO, 2023), **synthesising recent research on multimodal instructional** design through the framework of Cognitive Load Theory (CLT). It proposes design principles to enhance cognitive efficiency, accessibility, and relevance in e-learning across TVET and post-compulsory education settings.

Contextual Review

This contextual review positions three interrelated domains: (1) cognitive and instructional foundations, (2) inclusive and multimodal design frameworks, and (3) vocational and workplace learning contexts. Its purpose is to establish the conceptual and applied rationale underpinning the systematic literature review that follows.

Cognitive and Instructional Foundations

Effective digital learning design depends on deliberate management of learners' cognitive resources. CLT (Sweller et al., 2011) distinguishes intrinsic, extraneous, and germane load and provides design principles for optimising schema construction and long-term retention. In asynchronous settings,

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3 immediate scaffolding is often absent. Adult learners are therefore more vulnerable to overload amid
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5 competing professional and personal demands (Hurley, 2025).
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9 Although CLT is well established in formal education, its translation to lifelong and workplace
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11 learning remains limited. Existing studies such as Ally et al. (2022) and Papadakis et al. (2022)
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13 address digital learning broadly but seldom test how multimodal strategies influence motivation or
14
15 cognitive processing in self-paced environments. Similarly, George and Lal (2019) and El-Sabagh
16
17 (2021) evaluate multimedia use without assessing pedagogical efficiency or measurable learning
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19 outcomes. Extending CLT to adult and vocational contexts therefore represents both a theoretical and
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21 a practical research need.
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27 Inclusive and Multimodal Design Frameworks

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31 Inclusive e-learning design addresses not only accessibility but also motivation, persistence, and
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33 effective engagement. *Universal Design for Learning* (CAST, 2018) promotes multiple means of
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35 representation, engagement, and expression; principles congruent with CLT's emphasis on reducing
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37 extraneous load and optimising learner effort. Yet many e-learning environments remain dominated
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39 by static text or overly complex multimedia created without pedagogical grounding, which risks
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41 unnecessary cognitive load (Tamm, 2023).
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47 Adult and workplace learners frequently struggle to sustain motivation and self-regulation without
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49 embedded supports such as scaffolding, feedback, and adaptive pacing (Hurley, 2024; Eynon &
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51 Malmberg, 2021). Multimodal approaches that integrate text, narration, and interactive elements can
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53 accommodate diverse learner preferences. When aligned with CLT principles, such approaches also
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55 help sustain attention (Mayer, 2009; Sweller et al., 2011). In TVET and workplace contexts, where
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57 learners balance competing demands and variable digital confidence (Department for Education,
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2021; UNESCO, 2023), coherent multimodal design is essential. Poorly integrated media, by contrast, can increase extraneous load, underscoring the need for design grounded in both cognitive theory and inclusivity (CAST, 2018).

Vocational and Workplace Learning Contexts

Rapid technological change and the principles of *Industry 5.0* have elevated the role of TVET as a mechanism for workforce adaptability and inclusion. Yet, research on multimodal e-learning for adult, vocational, and workplace learners remains fragmented and disproportionately focused on higher education (Benabbes et al., 2023). Adults in employment often study intermittently, contend with competing responsibilities, and may lack confidence in digital environments (Eynon & Malmberg, 2021). These factors complicate engagement and heighten the relevance of instructional strategies that minimise cognitive load while sustaining motivation.

Extant research emphasises the need for qualitative, context-sensitive inquiry into how CLT can inform instructional design for adult and workplace learning (De Bruin et al., 2025; Vasilaki & Mavrogianni, 2025). Such inquiry is particularly salient within TVET because vocational learning frequently integrates procedural, visual, and applied tasks that depend on multimodal interaction (Pimblett et al., 2025).

When designed with cognitive efficiency in mind, CLT provides a robust framework for examining how multimodal resources can either optimise or overwhelm learners' working memory (Sweller et al., 2011). The *Global Report on Adult Learning and Education* (UNESCO, 2023) similarly highlights the urgency of creating cognitively supportive digital environments that enable meaningful and transferable skill acquisition. Yet, empirical evidence on the application of CLT to multimodal TVET design remains fragmented across disciplines and methodological traditions. Addressing this gap, the present review synthesises CLT-aligned multimodal strategies that advance inclusive,

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3 human-centred digital pedagogy in line with the *UK Skills for Jobs White Paper* (Department for
4 Education, 2021) and UNESCO's (2023) international TVET agenda for lifelong learning. The
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6 following section therefore outlines the review's purpose and guiding research questions.
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10 11 12 Research Purpose and Questions 13 14 15

16 This systematic review examines how CLT-informed multimodal design enhances motivation,
17 engagement, and knowledge retention among adult learners in asynchronous e-learning, identifying
18 approaches that address the cognitive and motivational challenges of digital upskilling.
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24 Responding to international priorities for inclusive and scalable lifelong learning (UNESCO, 2023;
25 WEF, 2025), this study underscores the importance of aligning digital instructional design with adult
26 learners' cognitive and motivational needs (Smith & Doe, 2025). By synthesising insights from CLT
27 and multimodal instructional strategies, the review contributes to evidence-based best practice in
28 workplace e-learning and adult education. Guided by the principles of CLT and informed by
29 contemporary research on multimodal learning, the review addresses the following research
30 questions:
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42 RQ1: How does multimodal instructional design influence adult learners' motivation, engagement,
43 and knowledge retention in asynchronous e-learning environments?
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47 RQ2: What challenges and limitations are reported in the instructional design of adult-focused
48 asynchronous digital learning, particularly those related to learner diversity and cognitive load?
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52 RQ3: What evidence exists for the effectiveness of CLT-aligned, multimodal design strategies in
53 improving adult learning outcomes in workplace and lifelong learning settings?
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Methodology

This study employs a Systematic Literature Review (SLR) to synthesise theoretical and empirical evidence on multimodal instructional design in asynchronous e-learning for adult learners. The review examines how digital instructional strategies influence learner motivation, engagement, and knowledge retention. Following the guidance of Tranfield et al. (2003), Booth et al. (2021) and Stokes and Wall (2014), the process involved structured searches across multiple databases, the application of transparent inclusion and exclusion criteria, and a thematic synthesis aligned with PRISMA 2020 reporting standards (Page et al., 2021).

An interpretivist stance underpins the review, recognising that learner experiences and instructional design practices are contextually constructed and mediated by perspective (Pretorius, 2024). The search strategy, inclusion criteria, and thematic synthesis were directly informed by the research questions outlined in the introduction, which explore the impact of multimodal instructional design within asynchronous TVET and workplace e-learning environments.

Conceptual Framework

The review is grounded in CLT, initially proposed by Sweller (1988) and expanded by Sweller, et al. (2011). CLT posits that learners possess a finite working memory capacity that constrains how much new information they can effectively process at any given time. It distinguishes between three types of cognitive load:

- **Intrinsic load** is related to the inherent complexity of the learning material and the learner's existing knowledge.
- **Extraneous load**, which results from ineffective instructional design, adds unnecessary cognitive burdens without aiding learning.

- **Germane load**, representing cognitive effort devoted to understanding and schema construction, directly contributes to effective learning.

Effective instructional design, particularly in digital environments, aims to minimise extraneous load and optimise germane load, thus enhancing motivation, engagement and knowledge retention. CLT is selected due to its explicit applicability to digital learning contexts, where poorly managed cognitive load frequently leads to disengagement and diminished learning outcomes. Building on CLT, Seufert et al. (2023) demonstrate that learners' ability to self-regulate is strongly influenced by perceived task difficulty and available cognitive resources, underscoring the need for adaptive, cognitively balanced design in asynchronous learning environments. CLT's emphasis on optimising intrinsic and extraneous load is particularly relevant to TVET contexts, where learners often juggle work-based responsibilities alongside digital learning (Jacobs et al., 2023).

Engagement Theory (Kearsley & Shneiderman, 1998) and Self-Determination Theory (Deci & Ryan 1985, 2000) were also considered. However, they were not the central focus due to their broader emphasis on social and motivational processes beyond the instructional domain.

Scope and Definitions

The review focused on asynchronous e-learning formats within adult education and workplace learning contexts. For the purposes of this review, asynchronous e-learning is defined as self-paced digital instruction accessed independently, without real-time interaction (Amiti, 2020). Included formats encompass online learning platforms, mobile learning, microlearning, and Massive Open Online Courses (MOOCs). Synchronous and blended learning models were excluded to maintain focus on solitary, digital environments typical of workplace and adult education.

Multi-modal e-learning is operationalised as an instructional design that deliberately integrates two or more complementary modes of representation: visual, auditory, read/write, or kinaesthetic to

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2
3 facilitate comprehension and skill acquisition. The categorisation of these modes of representation
4 follows the VARK typology (Fleming, 1995) for descriptive consistency, while theoretical
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6 follows the VARK typology (Fleming, 1995) for descriptive consistency, while theoretical
7
8 interpretation is guided by Mayer's (2021) 'Cognitive Theory of Multimedia Learning' and the
9
10 principles of Sweller et al. (2011). Together, these frameworks explain how multimodal integration
11
12 supports dual-channel processing, reduce extraneous load, and enhance schema construction. Studies
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14 were included where multimodality was an intentional pedagogical feature rather than incidental
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16 (e.g. text with an illustrative image only).
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20 Literature Search Strategy

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24 The review focused specifically on asynchronous e-learning formats within adult education and
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26 workplace learning contexts. The literature search was conducted between December 2023 and
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28 February 2024, following a structured, three-phase approach: preparation, searching, and quality
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30 assessment (Linnenluecke et al., 2019). The 'miner' technique (Breslin & Gatrell, 2020) supported
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32 the interpretivist paradigm, with searches conducted across 14 academic databases spanning
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34 education, psychology, health, and business disciplines. These included Emerald Insight, PsycINFO,
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36 British Education Index, MEDLINE, JSTOR, Taylor and Francis, ACM Digital Library, and
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38 ChesterRep. Supplementary searches were conducted using Google Scholar and Research Rabbit.
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44 A Boolean search strategy was employed using combinations of the core terms "*e-learning*,"
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46 "*multimodal learning*," "*instructional design*," "*cognitive load*," "*learner engagement*," and
47
48 "*asynchronous learning*." Contextual terms such as "*TVET*," "*vocational education*," and
49
50 "*workplace learning*" were added where relevant to reflect the study's focus on post-compulsory
51
52 and professional learning environments. Search strings were adapted for each database to account for
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54 differences in indexing systems, field tags, and disciplinary vocabularies, ensuring conceptual
55
56 equivalence while maintaining search precision. Full database search strings are provided in
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60 *Supplementary File S1*.

Inclusion and Exclusion Criteria

Studies focused on adult, vocational, or workplace learners in asynchronous e-learning within TVET or post-compulsory contexts were included. Exclusions applied to research on compulsory-education or undergraduate populations, synchronous-only delivery, and studies centred solely on technology adoption without a pedagogical dimension. Non-peer-reviewed and non-English publications were excluded to maintain quality and consistency, although seminal works predating 2019 were retained where theoretically essential to the framing of CLT and multimodal design. The search was limited to studies published from 2019 onwards to reflect the major post-COVID and Industry 4.0/5.0 shifts in asynchronous e-learning growth and implementation (Bozkurt & Sharma, 2021; Jacobs et al., 2023). Earlier seminal works (e.g., Sweller et al., 2011; Mayer, 2014) were retained only **where they provide the original theoretical formulations of Cognitive Load Theory or multimodal instructional design that contemporary studies still rely on. These works were identified due to their recurrent citation patterns in post-2019 literature and their role in defining foundational constructs.** (Grey literature was consulted for contextual insights but excluded from the final synthesis to maintain academic rigour (Booth et al., 2021).

Quality Screening and Appraisal

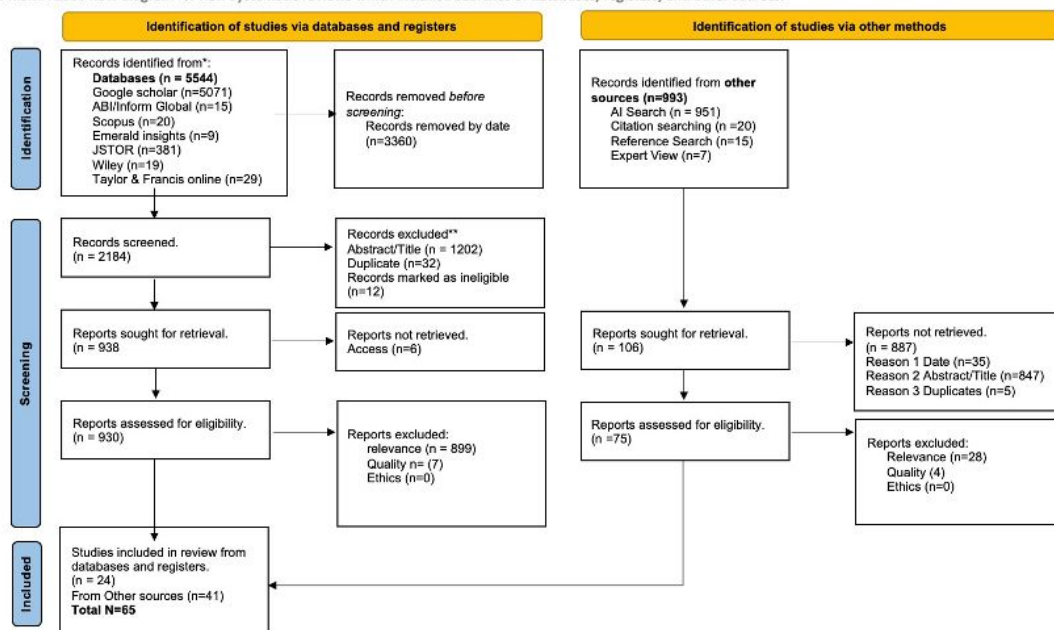
An initial screened pool of 2,184 records was identified. After removing duplicates and screening titles and abstracts for relevance, full texts were assessed for methodological quality, thematic alignment, and ethical integrity (Linnenluecke et al., 2019). This process resulted in a final set of 65 peer-reviewed studies. This approach proved particularly fruitful in identifying applied and practice-based studies often overlooked in database-only searches. Quality appraisal considered the clarity of research aims, design appropriateness, data collection methods, and relevance to the review objectives. Citation chaining and reference list scanning were used to identify additional sources.

The CRAAP framework (Blakeslee, 2004) was adopted in an adapted form as an appraisal tool suited to the diverse empirical and conceptual sources included in this review. It enabled consistent evaluation of methodological and contextual quality across the corpus. Studies were categorised as high, medium, or low quality; of the 65 included, 22 were rated high, 30 medium, and 13 low. Lower-rated papers were retained to preserve conceptual diversity but were interpretively weighted, contributing to descriptive rather than evidential claims within the synthesis. Sources were selected to reflect the theoretical, empirical, and methodological breadth underpinning the study. The PRISMA flow diagram (Figure 1) outlines the identification, screening, and inclusion process, and the completed PRISMA checklist is provided in *Supplementary File 2*.

To enhance transparency, *Supplementary File 3* presents a representative sample of key sources appraised using the adapted CRAAP criteria (Blakeslee, 2004). The list is not exhaustive but illustrates the balanced appraisal approach applied to all included literature.

Figure 1. PRISMA flow diagram illustrating the selection process for the research (adapted from Page et al, 2021)

PRISMA 2020 flow diagram for new systematic reviews which included searches of databases, registers, and other sources.



Data Extraction and Analysis

A thematic analysis was conducted using Braun and Clarke's six-phase framework (Braun & Clarke, 2006). Codes were generated inductively through repeated reading and extraction of key insights.

The analysis followed the sequential phases of familiarising with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report.

Potential themes were reviewed for coherence and theoretical alignment and considered through the framework of CLT and instructional design theory to ensure consistency with the review's conceptual framework and research questions.

To enhance rigour and transparency, a reflexive approach was maintained throughout the review (Campbell & Torrance, 2020). The first author conducted the initial screening, coding, and thematic synthesis while maintaining a reflective journal to record analytic decisions and potential biases.

Recognising the interpretivist stance underpinning the review, the author acknowledges that prior experience in instructional design and adult learning may have shaped the interpretation of evidence.

To mitigate this, analytic decisions were documented through a reflexive journal, and a second researcher independently reviewed the coding and quality appraisal processes (Berger, 2013). This collaborative validation supported methodological transparency, increased validity and reduced the potential influence of single-researcher bias, ensuring that interpretations remained grounded in the data. No automation tools were used during screening or extraction.

For each included study, data were extracted on author, year, country, participant characteristics, educational or workplace context, learning modality, intervention type, outcomes related to motivation, engagement, and knowledge retention, and reported cognitive or affective measures.

Funding source and methodological design were also recorded where available. Where participant information was unclear, studies were classified as adult or vocational if they described post-compulsory or workplace learning contexts. Themes were cross-checked against high-quality studies

to assess consistency; no substantial divergence was observed. The primary outcome domains were learner motivation, engagement, and knowledge retention, interpreted broadly to include self-reported measures, behavioural indicators, and learning-performance outcomes. All findings relevant to these domains were extracted, irrespective of measurement tool or timescale, provided they addressed digital instructional design in adult or vocational learning contexts. To ensure transparency between the research questions and analytical outcomes, Table 1 presents the alignment between each question, its analytical focus, and the corresponding themes derived from the synthesis.

Table 1. Alignment of research questions with analytical focus and thematic findings

Research Question (RQ)	Analytical Focus	Linked Themes / Subthemes
RQ1. How does multimodal instructional design influence motivation, engagement, and knowledge retention among adult learners in asynchronous e-learning?	Learner outcomes: motivation, engagement, cognitive load balance and knowledge retention.	Theme 1: Inconsistent instructional design; Theme 3: Motivation and engagement challenges; Theme 5: Multimodal strategies for cognitive efficiency.
RQ2. What multimodal design principles support inclusive and cognitively efficient learning within TVET and workplace e-learning contexts?	Instructional design: CLT-aligned and inclusive multimodal strategies.	Theme 1: Inconsistent instructional design; Theme 4: Persistence of learning-styles approaches; Theme 5: Multimodal strategies for cognitive efficiency.
RQ3. How is multimodal design conceptualised and applied in adult and vocational digital learning research between 2019 and 2024?	Research and practice trends. Methodological scope and contextual emphasis.	Theme 2: Barriers to lifelong learning; Theme 6: Limited focus on workplace learners.

Findings

The thematic analysis identifies six overarching themes that collectively address the review's research questions. These themes reflect how multimodal instructional design influences motivation, engagement, and knowledge retention, and how such design is conceptualised and applied within TVET and workplace e-learning contexts. Each theme is presented in turn, supported by illustrative

evidence and theoretical interpretation. Together, they provide an integrated synthesis aligned with the research questions outlined in Table 1. Across the six themes, findings are interpreted with reference to both high-quality empirical studies and lower-rigour descriptive or conceptual papers. Empirical studies are used to substantiate claims regarding effectiveness or outcomes, whereas descriptive or policy-based sources are used to provide contextual insight rather than causal evidence.

Theme 1: Inconsistent Instructional Design

The acceleration of Industry 5.0 and the espoused global commitments to lifelong learning have intensified the demand for flexible e-learning. (UNESCO, 2022, 2023) Yet, despite rapid expansion, online delivery often yields lower satisfaction and completion rates than blended models (B. Sedio, 2022; Zhang et al., 2019). The pandemic-driven shift to remote formats exposes persistent weaknesses in instructional design and pedagogy, with many institutions struggling to adapt to asynchronous learning (Ferrer et al., 2020; Zeng et al., 2022).

Barriers to effective e-learning extend beyond access to technology. Age, digital literacy, and cognitive differences influence engagement and performance (Al Rawashdeh et al., 2021; Al-Adwan et al., 2022). Current e-learning design remains biased toward visual and auditory modalities, providing limited support for kinaesthetic or experiential learners (Montebello et al., 2019; Ovtšarenko, 2023). While Sedio (2022) notes growing acceptance of multimodal and kinaesthetic strategies, she highlights inconsistencies in how they are conceptualised and applied. Crucially, increasing modality does not automatically enhance engagement; its effectiveness depends on instructional coherence and cognitive alignment.

Studies by Daoruang et al. (2019) and Lee (2019) indicate that interactive multimodal approaches can improve comprehension and satisfaction, though their small, discipline-specific samples

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3 constrain generalisability. Montebello et al. (2019) also found that integrating varied media and peer
4
5 feedback can strengthen engagement and conceptual mastery when grounded in mastery learning
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7 principles. However, few studies extend these findings to adult or workplace learning, limiting
8
9 external validity. The evidence therefore suggests that multimodal learning is *conditionally effective*:
10
11 it supports engagement and understanding only when pedagogical design and cognitive load are
12
13 carefully balanced.
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18 From a cognitive standpoint, multimodality is suggested to reduce overload only when channels are
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20 complementary (Sweller, 2023). Despite strong theoretical foundations in CLT (Sweller et al., 2011)
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22 and dual coding theory (Paivio, 1986), few studies operationalise these frameworks in practice. Most
23
24 rely on self-reported satisfaction rather than performance data, limiting claims of causal impact.
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28 Here, Clark and Mayer (2011) stress that effective e-learning requires clear objectives and alignment
29
30 with learners' prior knowledge, yet many designers prioritise technology over pedagogy (Narciss &
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32 Huth, 2021; B. Sedio, 2022). Concurrently, Sedio's (M. Sedio, 2022) study found that 40% of
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34 students perceived their e-tutors as lacking online instructional expertise, highlighting a persistent
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36 gap in pedagogical competence.
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40 Collectively, these findings reveal that while multimodal and adaptive strategies are conceptually
41
42 sound, their implementation is inconsistent. The overreliance on short-term, perceptual data and the
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44 dominance of higher education contexts restrict generalisability to workplace and TVET settings.
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46 Strengthening empirical foundations requires integrating cognitive frameworks into design practice
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48 and testing multimodal approaches across authentic, adult learning environments.
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53 **Theme 2: Lifelong Learning and Workplace Readiness: Opportunities and**
54 **Ongoing Barriers**
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3 The evolution of Industry 5.0 has reshaped workforce expectations, demanding continuous lifelong
4 learning and adaptability (DfE, 2023a; UNESCO, 2023). Workers are now expected to develop
5 digital fluency, critical thinking, and interpersonal skills that complement automation, yet these
6 requirements disproportionately challenge older employees with lower confidence in navigating
7 emerging technologies (Leng et al., 2022; Poláková et al., 2023). While many adults are motivated to
8 reskill or upskill across their careers, reduced self-efficacy and limited institutional support continue
9 to impede participation (Hetzner & Leen-Thomele, 2019).

10
11 Cabual (2021) rejects deficit views of age and learning potential, arguing that effective lifelong
12 learning depends less on age than on inclusive design and opportunity. This suggests instructional
13 strategies must foster confidence, accessibility, and intrinsic motivation: key determinants of
14 sustained engagement (Eynon & Malmberg, 2021; Varkey et al., 2023). Learners differ markedly in
15 their ability to adapt to new technologies and instructional demands with some studies revealing a
16 modest decline in productivity with age (Børing & Grøgaard, 2023), highlighting the need for
17 tailored upskilling that values experience while addressing evolving skill demands. Inclusive
18 pedagogical frameworks should move beyond remediation, instead leveraging older learners' tacit
19 knowledge through adaptive, multimodal design that encourages autonomy and transfer of learning.

20
21 E-learning offers a scalable pathway for lifelong education, particularly when it integrates active,
22 multimodal learning that strengthens digital literacy and problem-solving (Montebello et al., 2019;
23 Ovtšarenko, 2023). Yet, effectiveness hinges on pedagogical quality rather than delivery mode alone.
24 Studies such as that undertaken by Jacobs et al. (2023) demonstrate that online environments can
25 enhance workplace readiness and soft-skill development when grounded in sound instructional
26 design. Conversely, poorly contextualised initiatives risk diminishing motivation and skill transfer.
27 Here, Alhusban et al. (2023) found that inadequate alignment between digital tools and learner
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3 context led to weaker engagement and outcomes, echoing Aguilar's (2020) assertion that successful
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5 online learning depends on the integration of content expertise, pedagogy, and technology.
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9 Recent workplace-focused studies reinforce these findings. Chauvin et al. (2022) observed that
10
11 engagement in corporate multimodal training was shaped less by delivery mode than by
12
13 organisational flexibility and work role, highlighting the importance of contextual and motivational
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15 design. Similarly, Benabbes et al. (2023) demonstrated that context-aware recommender systems,
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17 when aligned with learner needs and work environments, improved satisfaction and completion rates.
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19 These studies underscore the need for workplace-specific adaptive e-learning models that integrate
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21 motivation and contextual relevance into design.
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27 Ultimately, the promise of lifelong e-learning remains conditional on the intersection of cognitive,
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29 motivational, and contextual factors. Policies must go beyond digital access to prioritise inclusive
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31 design principles that address learner diversity across age, background, and cognitive profile.
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33 Without such integration, technology-driven initiatives risk perpetuating exclusion rather than
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35 enabling lifelong learning for all.
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39 Theme 3: Motivation and Engagement in Asynchronous Learning

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43 Motivation and engagement remain persistent challenges in adult e-learning, particularly in
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45 asynchronous environments where social presence and accountability are limited (Ally et al., 2022;
46
47 Manzoor et al., 2022). Unlike synchronous or blended formats, asynchronous learning demands high
48
49 levels of autonomy and self-regulation; skills that are difficult to sustain without high-quality and
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51 pedagogically robust instructional design (Gomes & Bigotte de Almeida, 2023; Montebello et al.,
52
53 2019). Studies consistently show that motivation and engagement tends to decline over time in these
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55 settings, contributing to high attrition and inconsistent outcomes (Kizilcec et al., 2020).
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3 While Self-Determination Theory (Deci & Ryan, 1985) offers a useful lens for understanding
4 motivation through autonomy, competence, and relatedness, digital learning environments often fail
5 to nurture these elements effectively. Engagement Theory (Kearsley & Shneiderman, 1998) proposes
6 that meaningful engagement arises when learners *relate*, *create*, and *donate* knowledge within
7 authentic contexts. Yet, many asynchronous systems fall short of operationalising these principles,
8 resulting in experiences that are largely passive and isolating (B. Sedio, 2022; M. Sedio, 2022).
9

10 From a cognitive standpoint, Sweller et al. (2011, 2019) help explain why poorly structured digital
11 content can reduce motivation and retention. Overly complex materials overwhelm working memory,
12 while content that is too simple reduces challenge and interest. Seufert et al. (2023) describe this as
13 an *inverted U-shaped* relationship between task complexity and engagement, where optimal
14 challenge sustains focus and motivation. This balance is contingent on well-calibrated pacing and
15 instructional coherence rather than the mere inclusion of multiple modalities (Clark & Mayer, 2011;
16 Wang & Lajoie, 2023).
17

18 Although learners value the flexibility of asynchronous study, they frequently struggle to remain
19 motivated without structured feedback, interaction, or timely scaffolding. This is particularly relevant
20 for adult and workplace learners who often face competing responsibilities or limited confidence
21 with technology (Choy & Le, 2023; Zeng et al., 2022). Relevance and perceived utility also emerge
22 as critical motivational levers; adult learners engage more deeply when learning is clearly connected
23 to personal or professional outcomes (Girón-García et al., 2020; Khazanichi et al., 2022). Merrill's
24 (2002) principle of task-centred learning reinforces this, emphasising authentic, problem-based
25 application as essential for sustained engagement. Yet, many asynchronous modules still rely on
26 static, decontextualised content, neglecting learners' diverse needs and contexts (Ally et al., 2022;
27 Girón-García & Gargallo-Camarillas, 2020).
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3 In summary, motivation in asynchronous e-learning is not simply a function of flexibility but of
4 design intentionality. Effective environments balance cognitive load, embed motivational scaffolds,
5 and ensure content relevance to sustain adult engagement. Without these, autonomy can quickly
6 translate into disengagement, undermining the very flexibility asynchronous learning seeks to offer.
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13 Theme 4: Persistence of Learning Styles vs Cognitive Load Theory 14 15 16

17 Although the learning styles debate sits largely outside e-learning research, it provides essential
18 theoretical context for understanding how contemporary digital pedagogy conceptualises learner
19 diversity. The “meshing hypothesis”, the belief that aligning instruction with learners’ preferred
20 sensory modes improves learning, has historically influenced online course design and adaptive
21 system development. Yet, empirical evidence continues to challenge its validity. Coffield et al.
22 (2004, p. 2) observed that the “sheer number of dichotomies in the literature on learning styles
23 conveys something of the current conceptual confusion,” a conclusion since reinforced by studies
24 demonstrating little correlation between preferred styles and measurable learning outcomes
25 (Husmann & O’Loughlin, 2019; Kirschner, 2017; Nguyen et al., 2022).
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40 Recent research reaffirms this critique. Studies by Dinsmore et al. (2022), Nancekivell et al. (2020)
41 and Ristić et al. (2023) find that self-reported learning preferences rarely predict performance, while
42 Cabual (2021) and Martin et al. (2021) highlight that perceived style alignment may affect
43 motivation but not learning effectiveness. Despite the weak evidence base, belief in learning styles
44 remains persistent, often sustained by intuition and educational culture rather than data (Whitman,
45 2023). This persistence is not without consequence: design frameworks that prioritise preference
46 over process risk reinforcing superficial engagement rather than deep learning.
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57 CLT offers a more robust, evidence-based foundation for understanding learning in digital
58 environments (Sweller, 1988; Sweller et al., 2011). Rather than focusing on stylistic preference, CLT
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3 emphasises the optimisation of working memory by reducing extraneous load and strengthening
4 germane processing. Excessive attempts to personalise digital content to individual “styles” can
5
6 inadvertently increase cognitive load, fragment attention, and undermine knowledge integration; the
7
8 very effects CLT seeks to prevent.
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13 Consequently, the field has shifted from style-matching toward multimodal, adaptive design
14
15 approaches that manage cognitive load and support diverse learner engagement (El-Sabagh, 2021;
16
17 Montebello et al., 2019; Gomes & Bigotte de Almeida, 2023). This transition represents an important
18
19 theoretical evolution: from accommodating subjective preference to designing for cognitive
20
21 efficiency. The following theme builds on this foundation by examining how multimodal
22
23 instructional design can operationalise these principles to enhance engagement and retention in
24
25 asynchronous e-learning.
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30 31 Theme 5: Multimodal Design for Engagement and Retention 32

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34 As the relationships between classroom and online learning continue to develop and align (Bozkurt
35
36 & Sharma, 2021), a growing body of research supports the use of multimodal instructional strategies
37
38 to enhance learner engagement and retention, particularly in asynchronous digital environments
39
40 (Sedio, 2022, Zhang et al., 2019). Multimodal design refers to the integration of various content
41
42 formats, such as audio, visual, text, animation, and interactive components, to address diverse learner
43
44 preferences and cognitive needs (Clark & Mayer, 2011; Mayer, 2021). These strategies are
45
46 underpinned by CLT, which posits that well-structured multimodal materials can reduce extraneous
47
48 cognitive load while enhancing germane load, allowing learners to process and retain information
49
50 more effectively (Sweller et al., 2011).
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56 Multiple studies demonstrate the value of multimodal content in engaging adult learners by
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58 facilitating deeper cognitive processing. For instance, Mayer's (2021) principles of multimedia
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3 learning highlight that information presented through both visual and auditory channels promotes
4 better retention than text alone. Similarly, research by Lee (2019), Daoruang et al. (2019), and
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6 Montebello et al. (2019) confirms that combining modes of delivery can improve understanding,
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8 especially when aligned with real-world tasks and applications.
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13 However, the effectiveness of multimodal design is contingent on thoughtful implementation. Poorly
14 integrated multimedia can overwhelm learners and lead to cognitive overload, especially if irrelevant
15 or redundant content competes for attention (Mayer, 2021; Seufert et al., 2023; Wang et al., 2022).
16
17 Sedio (2022) cautions against the uncritical use of multimedia elements, noting that interactivity
18 must serve a clear instructional purpose; a view consistent with Sweller, van Merriënboer and Paas
19
20 (2019) who posit that design should support knowledge acquisition rather than entertainment.
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28 Despite these caveats, researchers agree that well-executed multimodal approaches support
29 engagement by accommodating different learning needs, reducing monotony, and enabling learners
30 to engage with content in ways that align with their cognitive strengths (Luo, 2023; Khazanichi et al.,
31
32 2022; Sedio, 2022b) For adult learners, particularly those juggling work and family responsibilities,
33 the ability to access content in flexible formats (e.g. listening to audio on commutes, watching short
34
35 videos, interacting with quizzes) can significantly increase motivation and course completion rates
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37 (Mustafa, 2021; Seufert et al., 2023; Terzieva et al., 2022; Barz et al., 2024).
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45 Recent studies also suggest that multimodal learning promotes deeper processing and reflection
46 when combined with techniques like spaced repetition, microlearning, and scenario-based tasks
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48 (Papadakis et al., 2022; Sennett & Vasquez, 2021). This approach aligns with Merrill's (2002)
49 emphasis on problem-based learning, where learners are more likely to retain knowledge when they
50 actively apply it in meaningful contexts. Nonetheless, multimodality alone is not a panacea. Several
51 authors highlight the importance of integrating pedagogical intent and instructional clarity into
52
53 multimedia elements to prevent distractions and maintain learner focus (Clark & Mayer, 2011;
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Mayer, 2021; Sedio, 2022b). The evidence indicates that multimodal design is most successful when grounded in cognitive science principles, aligned with learning objectives, and embedded within coherent instructional frameworks.

In summary, multimodal instructional design holds considerable promise for improving learner engagement and retention in asynchronous e-learning. When designed with care and pedagogical insight, it supports cognitive processing, accommodates diverse learning pathways, and increases the likelihood of successful learning outcomes among adult learners.

Theme 6: Gaps in Research on Adult and Workplace Learners

While digital learning environments continue to expand across sectors, there remains a notable lack of research focused specifically on adult learners and those engaging in e-learning within workplace contexts (Choy & Le, 2023; Hetzner & Leen-Thomele, 2019). Much of the academic literature in this space has been derived from studies involving university students in formal education settings, with limited transferability to adults returning to learning later in life or professionals seeking to upskill (Benabbes et al., 2023; Daoruang et al., 2019; El-Sabagh, 2021). As a result, the nuances of adult learning in practice, particularly in asynchronous contexts, are often underrepresented in the evidence base.

This gap is especially problematic given demographic shifts such as rising workforce participation among older adults (ONS, 2022) and the growing need for continuous learning in response to technological disruption (Leng et al., 2022; Li, 2022; Poláková et al., 2023). Adult learners, particularly those beyond traditional university age, often face unique barriers to engagement such as limited digital literacy, competing priorities, and reduced confidence in their learning ability (Eynon & Malmberg, 2021) exacerbated by concerns that the ability to manage cognitive load decreases significantly with age (Børing & Grøgaard, 2023). Yet, few instructional strategies have been

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3 developed to specifically address these obstacles, limiting the inclusivity of mainstream e-learning
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5 design for older or workplace learners.
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9 Several studies note that instructional design frameworks are frequently applied in overly generic
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11 ways, without adaptation for mature learners or working professionals (Gomes & Bigotte de
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13 Almeida, 2023; Razzak et al., 2019). As Mustafa (2021) and Manzoor et al. (2022) highlight, many
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15 learning design studies rely on simulations or controlled educational environments rather than real-
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17 world, situated contexts. This lack of ecological validity makes it difficult to assess how well e-
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19 learning interventions translate to adult learners' needs in workplace or continuing education settings.
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23 Moreover, the dominant methodological approaches used in existing research, typically quantitative
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25 or mixed methods, tend to prioritise generalisability over depth. There is a scarcity of high-quality
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27 qualitative studies that explore the lived experiences of adult learners in asynchronous environments
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29 (Nancekivell et al., 2020; Papadakis et al., 2022), creating a methodological imbalance that has led to
30
31 an under-theorisation of how motivation, engagement, and retention evolve in adult learners across
32
33 diverse settings and age cohorts. While adult learners are increasingly expected to engage in lifelong
34
35 learning, they are often treated as a monolithic group. Assumptions of digital competence can
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37 obscure individual needs, especially among those returning to education later in life. Addressing such
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39 assumptions is critical if digital education is to be genuinely inclusive.
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46 While some progress has been made in broadening participation and access, most interventions
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48 remain untailored and assume a homogenous learner population. The few studies that do examine
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50 older learners or workplace-specific training suggest that adult learners benefit from increased
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52 agency, relevance, and support structures (Hetzner & Leen-Thomele, 2019; Ovtšarenko, 2023).
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55 However, the findings remain fragmented and underdeveloped, pointing to a need for consolidated,
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57 practice-informed frameworks that support motivation and retention in adult cohorts.
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3 In summary, the literature reveals a persistent mismatch between the increasing demand for adult and
4 workplace e-learning and the limited scope of current research. Addressing this gap requires more
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6 workplace e-learning and the limited scope of current research. Addressing this gap requires more
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8 inclusive sampling, contextually grounded methodologies, and sustained attention to adult learning
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10 principles, workplace relevance, and cognitive-motivational diversity in design. Bridging this divide
11
12 is critical to ensuring that asynchronous digital environments support meaningful, equitable, lifelong
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14 learning. Without intentional change, there is a risk that digital learning will not only fail to close
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16 educational gaps but will widen them, particularly for groups already marginalised by age, access, or
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18 employment status.
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23 Discussion

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27 This chapter interprets the review findings in relation to the research questions and theoretical
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29 framework, discussing how the identified themes contribute to understanding. The discussion is
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31 structured around the three research questions, drawing connections to Cognitive Load Theory and
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33 the wider literature.
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37 Interpretation of Key Findings in Relation to Research Questions

40 41 **RQ1: How do multimodal instructional designs impact adult learners' motivation, engagement,** 42 43 **and knowledge retention in asynchronous e-learning?** 44

45
46 This review builds on the work of Mayer (2021) and Sedio (2022) and Seufert et al (2023) who
47
48 emphasise the value of dual and multimodal content in enhancing cognitive processing. Recent
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50 findings (Al-Adwan et al., 2022; Papadakis et al., 2022; Sennett & Vasquez, 2021; Seufert et al.,
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52 2023) further support this by showing how interactive and scenario-based formats can sustain learner
53
54 engagement and aid knowledge retention. However, this study contrasts with research that adopts
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56 overly technological approaches but which lack pedagogical grounding (Ovtšarenko, 2023),
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58 reaffirming that design quality, not just modality, determines efficacy. The results reinforce the view
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3 that CLT-informed design, when paired with meaningful multimodality, is key to supporting adult
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5 learning.
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9 **RQ2: What challenges are associated with designing effective asynchronous e-learning for**
10
11 **adult learners?**
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13 Echoing the concerns of Sedio (2022) and Ferrer et al. (2022), this review finds instructional design
14 inconsistencies persist across platforms, with many lacking user-centred design features, supporting
15 previous critiques by Mikic et al. (2022) and Ally et al (2022), while also highlighting the emerging
16 disconnect between content development and educational expertise, as noted by Gomes and Bigotte
17 de Almeida (2023). Furthermore, this study builds upon the work of Hetzner and Leen (2019) and
18 Børing and Grøgaard (2023) by identifying how motivation and digital confidence decline with age,
19 underscoring the importance of adaptable, age-inclusive design. It challenges the assumption still
20 present in much of the literature that younger, full-time learners represent the dominant user group
21 for e-learning design consideration.
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35 **RQ3: How does the application of CLT inform more inclusive, cognitively efficient learning**
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37 **environments for adult learners?**
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39 This review supports the position advanced by Sweller (2011) and Mayer (2021), and further
40 reinforced by recent studies (Seufert et al., 2023; Wang & Lajoie, 2023) that poorly structured or
41 overly dense content increases the risk of cognitive overload in learners. Recent contributions
42 (Fariani et al., 2022; Papadakis et al., 2022) show how CLT-aligned strategies, such as embedded
43 feedback, spaced repetition, and chunked content, can help manage this load effectively. This
44 review's findings resonate with Seufert et al. (2024), who argue that learner engagement declines
45 when task difficulty is too low or too high, highlighting the importance of instructional calibration in
46 multimodal e-learning. This review extends their work by explicitly linking these techniques to adult
47 learners in asynchronous contexts, a demographic often overlooked. By grounding its analysis in
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3 CLT, this review contrasts with less structured approaches in the literature that overemphasise
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5 learner preferences (e.g. learning styles) without considering cognitive architecture.
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9 Broader Implications and Research Gaps

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11 The findings align with concerns raised by Eynon and Malmberg (2021) and Hetzner and Leen-
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13 Thomele (2019) regarding the underrepresentation of older adults and workplace learners in digital
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15 learning research. This review also supports the work of Gomes and Almeida (2023), who note the
16
17 overuse of simulations rather than real-world user input in research design leading to several untested
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19 theoretical solutions. It contributes to this conversation by highlighting a methodological gap: a lack
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21 of high-quality qualitative studies exploring motivation and engagement from an interpretivist
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23 perspective.
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28 While some recent **small-scale and exploratory** studies, such as Benabbes et al. (2023), make
29
30 valuable contributions, the literature continues to prioritise academic settings over the applied adult
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32 learning environment. While the reviewed studies consistently highlight the benefits of multimodal
33
34 design for adult learners, notable tensions emerge across contexts. For instance, while Montebello et
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36 al. (2019) and Daoruang et al. (2019) report improved engagement through multimodal integration,
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38 **organisationally embedded and larger-scale empirical studies** like those of Chauvin et al. (2022)
39
40 emphasise that workplace engagement is shaped more by organisational flexibility than delivery
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42 mode. This contrast suggests that instructional design alone may be insufficient without contextual
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44 alignment. **While adaptive systems show promise in tailoring content within pilot-scale or design-**
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46 **oriented implementations (Benabbes et al., 2023), their reliance on learning-styles frameworks raises**
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48 **concerns about cognitive validity, as critiqued by Husmann and O'Loughlin (2019). Collectively,**
49
50 **this evidence suggests that instructional design alone may be insufficient without contextual**
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52 **alignment and cognitively grounded design principles.** These divergences underscore the need for
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54 more nuanced, context-sensitive research that interrogates not just what works, but for whom, under
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3 what conditions, and why. By critically synthesising these perspectives, the review highlights both
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5 the potential and the limitations of current multimodal strategies in adult and workplace e-learning.
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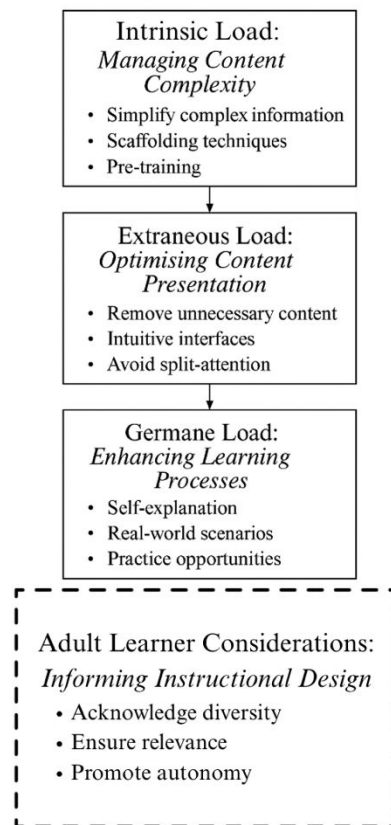
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9 Combining insights from CLT (Mayer, 2021; Sweller, 2011) and empirical research into multimodal
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11 instructional design, this review proposes a conceptual-practical framework to guide the
12
13 development of effective digital learning strategies for adult upskilling. In Figure 2, the framework
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15 highlights the sequential application of theoretical and practical elements. It begins with Intrinsic
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17 Load management, which focuses on simplifying complex information, applying scaffolding
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19 techniques, pre-training, and 'chunking up' learning content, ensuring learners can navigate essential
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21 content without cognitive overload.
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26 Following this, Extraneous Load reduction is addressed through the removal of unnecessary content,
27
28 the design of intuitive user interfaces, and minimising split-attention effects, optimising how content
29
30 is presented to learners. The third component, Germane Load enhancement, promotes deeper
31
32 learning processes by encouraging self-explanation, using real-world scenarios, and providing
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34 practice opportunities to support knowledge retention and application.
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39 Beneath these load-specific strategies, the framework integrates Adult Learner Considerations,
40
41 acknowledging diverse backgrounds, ensuring content relevance, and promoting autonomy. These
42
43 considerations inform instructional choices at every stage, ensuring that learning design aligns with
44
45 the cognitive, motivational, and contextual needs of adult learners. Finally, purposeful multimodal
46
47 integration ensures that text, audio, video, and interactive tasks are employed to support diverse
48
49 cognitive pathways without overwhelming the learner. When structured effectively, this multimodal
50
51 design fosters motivation, sustained engagement, and improved knowledge retention, driving
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53 meaningful learning outcomes. Ultimately, this approach supports workplace readiness and lifelong
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55 learning, preparing adaptable, digitally literate individuals aligned with evolving job market demands
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(Department for Education, 2021; UNESCO, 2023). The framework provides a practical structure that bridges cognitive theory with the applied realities of adult digital education.

Figure 1: Practical Conceptual Model: Applying CLT to Adult e-learning (First Author's own, 2025)



Implications for practice and policy

The findings of this review offer actionable insights for instructional designers, educators, and learning and development professionals developing asynchronous digital learning for adult learners. Techniques to utilise multimodal learning, such as ‘chunking up’ learning, scenario-based learning, embedded feedback loops, and spaced repetition, could reduce cognitive load and improve engagement and knowledge retention while supporting learner autonomy and motivation. Designers should consider Seufert’s (2023) inverted-U model of self-regulation, ensuring tasks are neither too

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3 simplistic nor cognitively overwhelming, particularly when learners are expected to navigate content
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5 independently.
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9 Flexibility, relevance to workplace practice, and opportunities for self-paced progression are
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11 essential features that support sustained engagement. These are particularly important within the
12
13 concept of Industry 5.0, where it is envisioned that learning systems must prioritise human-centric
14
15 values, adaptability, and inclusivity alongside technological advancement. Finally, as workforce
16
17 upskilling becomes increasingly critical considering automation and demographic shifts, these
18
19 findings underscore the strategic importance of inclusive and pedagogically sound e-learning design.
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21 Developing digital learning that is adaptable, accessible, and aligned with Industry 5.0 priorities will
22
23 be key to enabling critical lifelong learning strategies and successful outcomes across age groups and
24
25 professional contexts. In addition, lifelong learning initiatives must proactively scaffold work-
26
27 readiness skills, particularly for adults balancing employment and study. Training providers are
28
29 encouraged to design context-sensitive, workplace-aligned e-learning experiences, moving beyond
30
31 generic digital modules to address the specific needs of adult and vocational learners. Appendix 1
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33 provides a practitioner checklist derived from the review's findings, supporting instructional
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35 designers and trainers to apply CLT-informed, inclusive design strategies in multimodal workplace
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37 and vocational e-learning.
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45 **Conclusion**

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48 This review provides a comprehensive synthesis of how multimodal instructional design, informed
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50 by CLT principles, influences motivation, engagement and knowledge retention in asynchronous e-
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52 learning environments for adult learners. Synthesising 65 peer-reviewed studies, the review
53
54 identified six key themes, including inconsistent instructional design, the role of lifelong learning,
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56 challenges in maintaining motivation, continued reliance on learning styles theory, benefits of
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58 multimodal approaches and the underrepresentation of adult learners in research.
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3 The findings reinforce the importance of cognitively grounded instructional strategies that move
4 beyond visual appeal to support deeper engagement and learning outcomes. Aligning design with
5 adult learning theory and CLT principles can enhance the inclusivity and effectiveness of
6 asynchronous e-learning for a diverse, ageing workforce. Despite growing policy emphasis on
7 lifelong learning and digital upskilling, workplace learners remain significantly underrepresented in
8 the current evidence base. Much of the literature continues to focus on academic settings,
9 overlooking the unique cognitive, motivational, and contextual needs of adults engaged in
10 professional development. Addressing this gap is essential to ensure that asynchronous e-learning
11 environments are not only inclusive but also practically relevant for diverse workplace contexts.
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25 A key strength of this review is its rigorous, transparent methodology, which followed a structured
26 protocol for study selection, appraisal and synthesis (Booth et al., 2021). In addition, the use of CLT
27 and instructional design theory enabled a focused, theoretically grounded synthesis. The reviewer's
28 expertise in cognitive psychology and learning and development further enhanced the review's depth
29 and relevance. Limitations include the restricted timeframe and language (English-language studies
30 published from 2019 onwards) and the disciplinary concentration of available research, which was
31 predominantly situated within psychology, education, and engineering. This distribution may
32 underrepresent workplace learning studies from sectors such as business, healthcare, or public policy.
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43 Although screening and coding were independently verified by a second researcher to enhance
44 reliability, interpretive bias remains possible due to the qualitative nature of thematic synthesis.
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48 Additionally, variability in methodological reporting across included studies limited the depth of
49 comparative analysis. **Overall confidence in the evidence was judged moderate, given consistent
50 thematic convergence across studies of differing methodological scope and evidential strength.**
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56 Future research should extend CLT into longitudinal and applied contexts to examine how
57 multimodal e-learning supports knowledge retention and transfer to workplace practice. Further
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3 studies are also needed on adaptive instructional systems that dynamically regulate cognitive load in
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5 response to learners' prior knowledge, experience, and digital literacy. Finally, greater attention
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7 should be given to the economic and institutional feasibility of implementing CLT-informed
8
9 multimodal design within TVET and adult learning sectors, including analyses of cost-effectiveness,
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11 scalability, and organisational capacity. Collectively, these directions will help build a stronger
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13 evidence base for inclusive, cognitively efficient e-learning design across vocational and workplace
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15 settings.
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20 This review contributes to the growing discourse on adult digital learning and underscores the urgent
21
22 need for more applied, context-specific research. It offers a foundation for developing evidence-
23
24 informed, human-centric, cognitively efficient digital learning environments aligned with the
25
26 priorities of Industry 5.0, balancing technological innovation with inclusivity and lifelong learning.
27
28 The authors declare no competing interests. Data-extraction coding and tables are available on
29
30 request.
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Appendix

Appendix 1: Practitioner Checklist: Designing CLT-Aligned Multimodal Asynchronous Learning for Adults

Focus Area	Practitioner Actions
Manage Cognitive Load	<p>Reduce extraneous load: Remove unnecessary text, imagery, or animation.</p> <p>Optimise intrinsic load: Chunk content into short segments (\leq six key ideas per screen) and sequence simple to complex.</p> <p>Increase germane load: Include reflection prompts and scenario-based practice.</p>
Design for Multimodal Learning	<p>Integrate complementary modes: Combine text with narration or video where each adds value and provide options for learners.</p> <p>Support dual-channel processing: Pair diagrams with spoken explanations.</p> <p>Provide flexible access: Offer transcripts, captions, and downloadable summaries.</p>
Motivate and engage	<p>Promote relevance: Begin with <i>'Why this learning matters for your role or to you'</i>.</p> <p>Sustain motivation: Use microlearning (15-20 minutes) with spaced reinforcement (48 hours, 1 week, 1 month).</p> <p>Encourage autonomy: Allow goal setting and self-paced exploration.</p>
Reinforce and evaluate	<p>Reinforce learning: Include quizzes within and at the end of modules, reflection prompts with feedback.</p> <p>Encourage application: Ask learners to apply new skills to workplace processes, test safely through branching scenarios.</p> <p>Measure impact: Track engagement and confidence before and after training.</p>
Ensure Accessibility and Inclusion	<p>Apply Universal Design for Learning principles.</p> <p>Support digital confidence: Provide orientation and assistive tech compatibility.</p> <p>Embed ethical awareness: Address data responsibility and bias avoidance.</p>

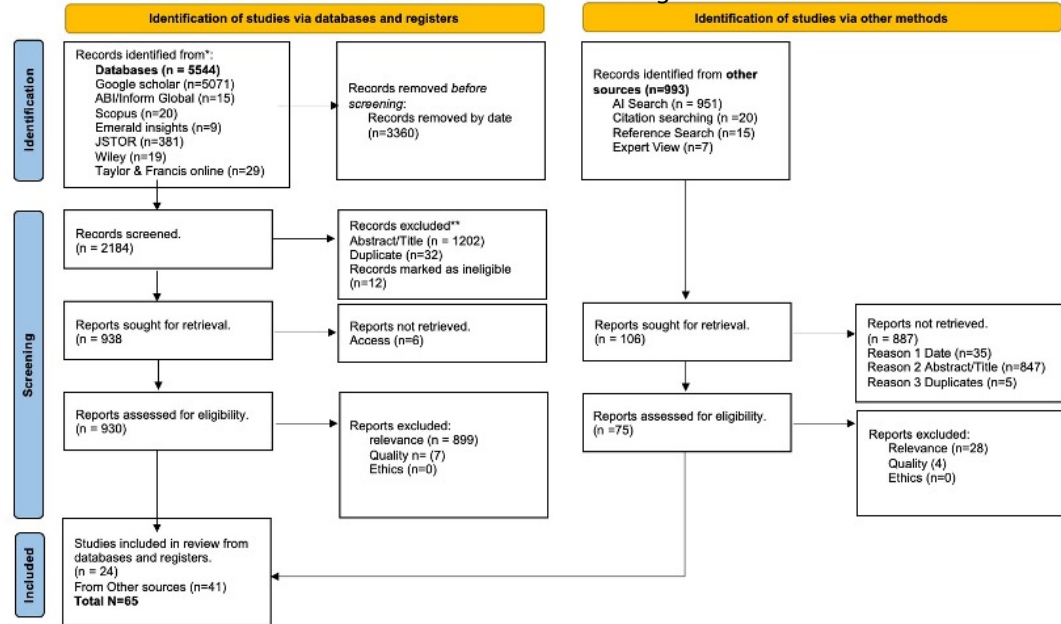


Table 1. Alignment of research questions with analytical focus and thematic findings

Research Question (RQ)	Analytical Focus	Linked Themes / Subthemes
RQ1. How does multimodal instructional design influence motivation, engagement, and knowledge retention among adult learners in asynchronous e-learning?	Learner outcomes: motivation, engagement, cognitive load balance and knowledge retention.	Theme 1: Inconsistent instructional design; Theme 3: Motivation and engagement challenges; Theme 5: Multimodal strategies for cognitive efficiency.
RQ2. What multimodal design principles support inclusive and cognitively efficient learning within TVET and workplace e-learning contexts?	Instructional design: CLT-aligned and inclusive multimodal strategies.	Theme 1: Inconsistent instructional design; Theme 4: Persistence of learning-styles approaches; Theme 5: Multimodal strategies for cognitive efficiency.
RQ3. How is multimodal design conceptualised and applied in adult and vocational digital learning research between 2019 and 2024?	Research and practice trends. Methodological scope and contextual emphasis.	Theme 2: Barriers to lifelong learning; Theme 6: Limited focus on workplace learners.

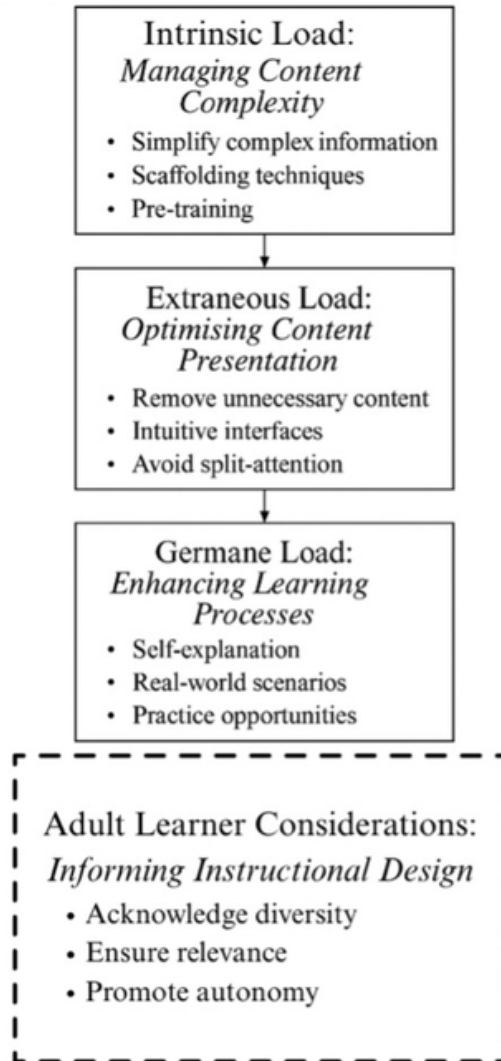


Figure 2: Practical Conceptual Model: Applying CLT to Adult e-learning (First Author's own, 2025)

79x122mm (150 x 150 DPI)

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Ensure Accessibility and Inclusion	<p>Apply Universal Design for Learning principles.</p> <p>Support digital confidence: Provide orientation and assistive tech compatibility.</p> <p>Embed ethical awareness: Address data responsibility and bias avoidance.</p>

S1: Full Boolean Search Strategy and Strings

Database / Source	Full Search String (Boolean Logic)	Limits / Filters	Date Range	Notes
Google Scholar	("asynchronous learning" OR "online learning") AND ("multimodal" OR "multimedia instruction") AND ("adult learners" OR "workplace learning" OR "TVET")	English, Peer-reviewed	2019–2024	Largest yield; included both academic and grey literature, filtered manually.
ABI/Inform Global	("vocational" OR "workplace learning") AND ("e-learning" OR "asynchronous") AND ("instructional design" OR "cognitive load")	English, peer-reviewed	2019–2024	Business and training focus; low yield.
Scopus	("asynchronous" OR "self-paced") AND ("multimodal" OR "multimedia") AND ("adult" OR "workplace")	English, Peer-reviewed	2019–2024	Broad disciplinary coverage; duplicates removed.
Emerald Insight	("e-learning" OR "online learning") AND ("instructional design" OR "multimodal learning") AND ("TVET" OR "workplace learning")	English, peer-reviewed	2019–2024	Education and training focus; core source.
JSTOR	("multimodal" OR "multimedia") AND ("instructional design" OR "cognitive load")	English, Peer-reviewed	2019–2024	Theoretical and historical sources; included selective articles.
Wiley Online Library	("asynchronous" OR "digital learning") AND ("cognitive load" OR "CLT")	English, Peer reviewed	2019–2024	Low yield; overlap with Taylor & Francis.
Taylor & Francis Online	("multimodal" OR "multimedia") AND ("adult learners" OR "workplace")	English, peer-reviewed	2019–2024	Education and psychology focus.
PsycINFO	("cognitive load" OR "Cognitive Load Theory") AND ("asynchronous learning" OR "digital learning") AND ("motivation" OR "engagement" OR "retention")	English, Peer reviewed	2019–2024	Added for theoretical grounding.
British Education Index	("adult education" OR "TVET") AND ("digital learning" OR "instructional design")	English, Peer reviewed	2019–2024	UK and vocational focus.
MEDLINE	("digital training" OR "e-learning") AND ("adult learners" OR "vocational trainees") AND ("instructional design" OR "cognitive load")	English, Peer reviewed	2019–2024	Focused on health and technical training.
ChesterRep	("TVET" OR "workplace learning") AND ("e-learning" OR "multimodal")	Repository search	2019–2024	Institutional and regional studies.
AI Search (Research Rabbit)	"Cognitive Load Theory" AND "multimodal asynchronous learning"	—	2019–2024	Used for forward/backward citation tracing.

Citation Search	Manual citation chasing via Google Scholar and Scopus	—	2019–2024	Identified additional relevant studies.
Expert View / Reference Search	Consultation and cross-reference with institutional experts and bibliographies	—	2019–2024	Used for validation of scope.

Note. Fourteen databases and supplementary sources were searched in total, aligned with PRISMA 2020 reporting. Low-yield databases (e.g., Wiley, ABI/Inform, MEDLINE) are retained for transparency.

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PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	
Certainty	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	



PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
assessment			
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	
Study characteristics	17	Cite each included study and present its characteristics.	
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	
	23b	Discuss any limitations of the evidence included in the review.	
	23c	Discuss any limitations of the review processes used.	
	23d	Discuss implications of the results for practice, policy, and future research.	
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	
Competing interests	26	Declare any competing interests of review authors.	
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	



PRISMA 2020 Checklist

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Education + Training

Supplementary File S3. Characteristics and Quality Appraisal of Included Studies

This supplementary table presents a representative extract of the studies included in the review. Each entry summarises key characteristics (author, year, country, design, modality, and findings) and incorporates a CRAAP-based quality appraisal (Blakeslee, 2004) adapted for methodological and contextual assessment. CRAAP ratings (High / Medium / Low) are integrated within the table rather than reported separately.

Author(s) (Year)	Context	Design / Participants	Focus & Modalities	Key Findings	CRAAP Rating
(Pangeni & Karki, 2021)	TVET	Mixed methods; Nepalese TVET learners	Multimodal blended asynchronous learning	Multimedia integration increased engagement and applied learning; need for consistent design models.	High
(Mustafa, 2020)	TVET / Workplace	Conceptual and system design analysis	Personalised adaptive e- learning using strategic knowledge and learning styles	Argues adaptive systems enhance performance when linked to learner preference; limited empirical data.	Medium
(Smyrnova- Trybulska et al., 2022)	TVET / Cross- border	Comparative qualitative; 180 HE/TVET students (Poland & Ukraine)	Adaptive multimodal e- learning via Moodle	Cross-national comparison showed preference for adaptive personalised systems; warns against over- automation.	High
(Chauvin et al., 2022)	Workplace	Mixed methods; employees in corporate multimodal training	Multimodal workplace training and learner engagement	Engagement shaped more by work role and flexibility than delivery mode; underlines motivational design importance.	High
(Benabbes et al., 2023)	Workplace	Quantitative; 714 learners, Morocco	Context-aware recommender e-learning using learning styles	Adaptive recommendations improved satisfaction and completion; supports context- integrated design.	High
(B. Sedio, A, 2022)	Workplace / ODeL	Mixed methods; 350 ODeL students, South Africa	Instructional strategies for design process in e-learning	E-tutors lacked multimodal pedagogy knowledge; calls for tactile, kinesthetic	Medium

				strategies in digital skill learning.	
(El-Sabagh, 2021)	Higher Education	Quantitative; 118 students, Egypt	Adaptive e-learning using VARK learning styles	Adaptive design boosted engagement and satisfaction vs. standard e-learning.	High
(Daoruang et al., 2019)	Higher Education	Quantitative; 47 IT undergraduates, Thailand	Blended multimodal (VARK) learning	Multimodal students scored higher than unimodal; supports multimodal engagement.	Medium
(Lee, 2019)	Higher Education	Mixed methods; 50 English majors, Taiwan	Technology-mediated multimodal (VARK+) presentation training	Students valued multimodal activities but noted overload risk from excessive modes.	Medium
(Ristić et al., 2023)	Higher Education	Quantitative; 228 students, Serbia	Adaptive Moodle-based e-learning (VAK model)	Adaptive design improved retention and motivation; kinesthetic learners performed best.	High
(Ferrer et al., 2020)	Higher Education	Quantitative; 574 undergraduates, Australia	Online learning motivation and engagement study	Attitude to online learning moderated motivation–engagement link; supportive design improves outcomes.	High

Note: The full corpus of included studies and the complete extraction dataset are available from the corresponding author upon reasonable request.