International Certification of Digital Literacy as a Micro-Credential in Malaysia: Enhancing University Students' Readiness for Industry 4.0 and Digital Economy

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ABSTRACT

International certification offers universities a portable way to verify students' digital competence, but its value relies on more than just a visible badge. This systematic review investigates whether i certification can serve as a micro-credential to strengthen Malaysian university students' readiness for the digital economy. Following PRISMA 2020 guidelines, this study reviewed freely accessible English-language journal articles published between January 2021 and January 2026. Ultimately, thirty-one studies met the eligibility and quality criteria for thematic synthesis. The synthesized evidence reveals several key themes. First, digital competence is multidimensional, encompassing data literacy, communication, content creation, safety, and problem solving. Second, Malaysian employers report a high demand for these skills alongside noticeable graduate skill gaps, while learner studies show that strong digital abilities improve perceived employability. Third, although micro-credentials make skills visible and portable, their broader recognition suffers from inconsistent definitions, varying quality assurance, and limited employer familiarity. Finally, direct recent evidence on the ICDL itself is remarkably scarce. This study found only one eligible outcome study, and none evaluated Malaysian students or actual employment outcomes. Consequently, this review supports a conditional proposition rather than a definitive claim. The ICDL is most credible as a higher education micro-credential in Malaysia when it is demand-led, performance-assessed, verifiable, integrated into the curriculum, and co-designed with employers. To support this, this study proposes a validated digital-readiness pathway to guide future pilot and longitudinal research in Malaysia.

Keywords: ICDL; digital literacy; digital competence; micro-credentials; graduate employability

INTRODUCTION

Digital transformation is altering the tasks, tools, and evidence that organisations use to recruit, deploy, and develop talent. In the Industry 4.0 environment, graduates must go beyond basic office applications. They are expected to locate and evaluate information, collaborate through digital platforms, create and communicate digital content, protect data and identity, solve technology-mediated problems, and adapt as tools change. These capacities are essential for participation in data-rich, automated, and networked workplaces. Consequently, international research treats digital literacy as a multidimensional competence rather than a simple binary distinction between users and non-users (Tinmaz et al., 2022; Tzafilkou et al., 2022; Zhao et al., 2021).

Despite these multidimensional requirements, a practical challenge persists. Frequent technology use does not automatically equate to competent, safe, or transferable performance. University students may feel confident in

their everyday use of technology while retaining blind spots in information judgment, advanced content production, cybersecurity, troubleshooting, or applying digital tools to unfamiliar professional tasks. Self-reported measures often inflate this perceived competence, and traditional degree transcripts rarely capture granular digital achievements (González-Mujico.,2024). As a result, employers might confirm an applicant has completed a program without knowing if they can execute a defined set of digital tasks at a verified level.

The Malaysian literature makes this disconnect concrete. Employer surveys highlight a strong demand for information and data literacy, digital content creation, and problem-solving, alongside notable gaps across several digital skill domains among recent graduates (Tee, Song, et al., 2024; Tee, Wong, et al., 2024). A Malaysian youth study further links the acquisition of specific digital skills to perceived employability and demonstrates that course quality actively shapes these relationships (Kee et al., 2023). Studies on socio-digital capability and online learning similarly warn that basic technology access is insufficient, as the quality of learning design, engagement, and the integration of social and digital skills heavily influence final outcomes (Rahmat et al., 2022; Wan Mohamad et al., 2025). The underlying problem is thus both educational and informational. Universities must simultaneously help students acquire relevant competencies and make those competencies highly visible to prospective employers.

To bridge this informational gap, micro-credentials have emerged as a popular response. They represent shorter, focused units of assessed learning that can be displayed, verified, and combined far more flexibly than conventional academic awards. International reviews caution, however, that the term itself is used inconsistently. Certificates of attendance, digital badges, credit-bearing short courses, and externally assessed industry certifications might all be labelled as micro-credentials even though their evidential value differs dramatically (Ahsan et al., 2023; McGreal & Olcott, 2022; Tamoliune et al., 2023). Broad recognition ultimately depends on clear learning outcomes, valid assessment, strict quality assurance, trustworthy metadata, portability, and a clear connection to formal qualifications and workplace needs.

The international digital certification provider offers standardised modules and rigorous assessment of digital skills. Currently, many reliable international digital literacy certifications offer broad scope and test-based awards, making them plausible for candidates pursuing micro-credentialing. Even so, certification cannot be assumed to improve employability simply because it is internationally recognised or digitally displayed (Varadarajan et al., 2023). The complete causal chain from training to competence, from competence to a trusted credential signal, and from that signal to tangible employment outcomes must be demonstrated. However, he available Malaysian evidence focuses on digital skills and micro-credentials in a broad sense, while recent ICDL-specific evidence remains geographically distant and limited in scale (Al-Othman et al., 2021).

Three distinct gaps emerge from this existing literature. First, the evidence base is heavily fragmented across digital competence research, micro-credential design, employer demand, and industry certification. Very few studies successfully connect all four areas. Second, direct English-language open-access research published after 2020 on specific ICDL outcomes is scarce, and current searches locate no eligible studies evaluating the ICDL among Malaysian university students. Third, outcomes are predominantly measured through perceptions, intentions, or self-reported competence rather than objective metrics. There is limited use of performance tests, employer recognition tracking, actual recruitment decisions, or longitudinal employment data. These compounded gaps prevent researchers from making a strong claim that an ICDL award inherently improves Malaysian graduate employability on its own.

Accordingly, this study provides a PRISMA 2020 systematic review of recent and accessible international and Malaysian evidence. Ultimately, the review addresses the central question of under what design and recognition conditions the ICDL can plausibly function as a micro-credential that enhances Malaysian university students' readiness for Industry 4.0 and the digital economy. The review targets several core objectives (RO):

RO1: Clarify the relationships among digital literacy, micro-credentials, the ICDL, Industry 4.0 readiness, and general employability.

RO2: Identify the specific digital competence demands and gaps reported for Malaysian students, youth, and graduates.

RO3: Synthesize the evidence on the specific conditions under which micro-credentials become credible signals of competence.

RO4: Determine the true extent and limitations of recent ICDL-specific evidence.

RO5: Develop an evidence-based pathway for future Malaysian implementation and evaluation.

The remainder of the paper follows a structured sequence. Section 2 reviews the conceptual and empiricalliterature on digital competence, work readiness, micro-credentials, credential signaling, the ICDL, and the Malaysian context. Section 3 describes the PRISMA-based search, eligibility criteria, quality appraisal, data extraction, and synthesis procedures. Section 4 exclusively reports the findings of the review. Section 5 discusses the implications of these results and establishes the boundaries of the associated claims. Finally, Section 6 concludes the paper, sets out actionable recommendations, identifies inherent limitations, and proposes clear directions for future research.

LITERATURE REVIEW

Digital literacy and digital competence

Digital literacy has evolved from basic computer operation into a broader capacity to act effectively, critically, safely and creatively within digital environments. While the terms digital literacy, digital competence and digital skills frequently overlap, they are not entirely identical. The word skills generally refers to executable capabilities. Competence normally combines knowledge, skills and attitudes within a specific context. Literacy foregrounds purposeful and critical participation. Building on these distinctions, Tinmaz et al. show that recent research continues to organize the field around literacies, competencies, skills and forms of thinking rather than relying on a single technical checklist (Tinmaz et al., 2022). Caroline et al. similarly find no generic measure that adequately connects digital literacy with employability and innovative work behavior across diverse business contexts (Caroline et al., 2025).

Despite this terminological variation, five functional domains consistently recur throughout the literature. The first domain is information and data literacy, which encompasses search, evaluation, organization and interpretation. The second involves communication and collaboration, covering professional interaction, participation, netiquette and digital identity management. A third domain focuses on digital content creation. This area ranges from producing, editing and integrating basic content to understanding automation, coding and intellectual property constraints at more advanced levels. Safety constitutes the fourth domain, highlighting cybersecurity, privacy, wellbeing and responsible practice. Finally, problem solving requires selecting appropriate tools, troubleshooting, adapting and innovating. To capture this complexity, Tzafilkou et al. operationalize student digital competence using multiple components rather than a single aggregate score (Tzafilkou et al., 2022). Furthermore, Zhao et al. and Vishnu et al. demonstrate that both experience and context heavily shape how students develop these competencies (Vishnu et al., 2022; Zhao et al., 2021).

Industry 4.0, the digital economy and graduate readiness

Industry 4.0 integrates cyber-physical systems, data, automation, cloud services, artificial intelligence and connected work. It does not eliminate the need for human capability. Instead, it fundamentally changes the combination of capabilities required. Islam describes employability for Industry 4.0 as a mix of technical, cognitive and interpersonal resources (Islam, 2022). Supporting this view, Croatian graduate evidence positions digital competence alongside generic competence rather than treating it as a substitute for communication, learning or problem solving (Pažur Aničić et al., 2023). Engineering students' views of Education 4.0 further reinforce the importance of problem-based work, creativity, analytical and critical thinking, communication and technical information technology competence (Beke & Tick, 2024).

Building on these diverse capability requirements, workplace readiness is consequently broader than employability but narrower than actual employment. Readiness includes demonstrated competence, the confidence to apply it, adaptability, work-relevant judgement and the ability to clearly communicate evidence of capability. Employment, by contrast, is influenced by labour demand, occupation, location, networks, prior experience and discrimination alongside raw competence. While studies that measure perceived employability provide meaningful attitudinal evidence, they cannot establish direct effects on hiring, wages, job quality or retention. Therefore, this review maintains a strict outcome hierarchy throughout the synthesis to distinguish between these factors.

Examining how these dynamics play out locally, Malaysian studies identify a significant applied skills problem within this wider economic transition. Tee et al. report gaps in all employer-rated areas except information and data literacy (Tee, Wong, et al., 2024). Furthermore, their related employer study identifies strong future demand specifically for problem solving and safety (Tee, Song, et al., 2024). Kee et al. find positive relationships between several digital skill domains and perceived employability among youth, noting that course quality acts as a mediator for selected domains (Kee et al., 2023). Rahmat et al. also add that employers highly value socio-digital integration (Rahmat et al., 2022). Together, these results support a comprehensive model in which digital capabilities must be practically applied in conjunction with communication, judgement and the specific work context.

Micro-credentials: definition, purposes and recognition

Micro-credentials occupy a unique space between informal learning and formal academic qualifications. Brown et al. describes a rapidly changing credential ecology in higher education (Brown et al., 2021). Meanwhile, Selvaratnam and Sankey alongside McGreal and Olcott emphasize the necessity of making strategic decisions regarding purpose, academic level, quality and institutional fit (McGreal & Olcott, 2022; Selvaratnam & Sankey, 2025). Across the reviewed literature, recurring purposes for these programs include rapid upskilling and reskilling, flexible educational access, recognition of prior or non-formal learning, the creation of stackable pathways and closer alignment with occupational needs (Ahsan et al., 2023; Tamoliune et al., 2023; Yıldırım et al., 2025).

To fully understand how these pathways function, a useful analytical distinction must be drawn between the learning experience, the formal assessment and the final credential object. The course provides structured opportunities to learn, the assessment generates concrete evidence of that learning, and the credential publicly communicates the resulting claim. Reed et al. show that faculty design principles frequently connect micro-credentials directly to assessment outcomes (Reed et al., 2024). They also reveal, however, significant uncertainty regarding what external stakeholders actually understand about these awards. Addressing this gap, Maina et al. demonstrate how employability skills can be effectively documented through a collaborative methodology involving lecturers, students and employers (Maina et al., 2022). Their work highlights that e-portfolios and digital micro-credentials significantly improve the visibility and transparency of learning. Ultimately, any credential remains credible only to the extent that its underlying claims can be traced back to valid and reliable evidence.

Even with valid evidence, widespread market recognition is not guaranteed. Varadarajan et al. identify significant stakeholder concerns regarding consistency, academic integrity and formal recognition, noting that successful implementation demands substantial institutional support (Varadarajan et al., 2023). Compounding these challenges, Orman et al. observe that actual employer recognition of these alternative awards remains vastly under-researched (Orman et al., 2023). Ha et al. similarly frame micro-credential adoption as a complex multi-stakeholder and non-zero-sum problem (Ha et al., 2023). They argue that market value depends on strategic alignment rather than simply substituting short credentials for traditional degrees. While international cases show considerable promise, they also consistently reveal the urgent need for transparent assessment, rigorous accreditation and formal recognition arrangements (Farias-Gaytan et al., 2023; Griffiths et al., 2024).

Alongside the challenge of industry recognition, equity serves as a crucial secondary boundary condition for micro-credential implementation. While programmatic flexibility may greatly benefit working learners or those seeking targeted professional development, several barriers can inadvertently reproduce existing

systemic disadvantages. Issues such as tuition fees, equipment costs, internet connectivity, language barriers, disability access and a lack of prior digital confidence must be addressed. Highlighting these concerns, Desmarchelier and Cary caution that micro-credentials should be rigorously evaluated against just and equitable purposes rather than automatically assumed to democratize education (Desmarchelier & Cary, 2022). A digital certification initiative can therefore widen workforce participation only if equitable access to preparation, assessment and re-sitting is designed intentionally from the outset.

International certification as a micro-credential

Industry and international certifications differ from many university-issued micro-credentials because their assessment standards and branding originate outside the institution. While this external origin can support

portability and comparability, it also raises important questions regarding curricular fit, governance, cost, data stewardship and the actual breadth of learning represented. Consequently, the present review treats the ICDL as a candidate micro-credential only when four minimum conditions are met. These conditions require a bounded set of stated outcomes, an identity-linked assessment against a defined standard, a verifiable result with meaningful metadata and a quality-assured relationship to a formal learning pathway. Simple attendance alone does not satisfy this rigorous definition.

Applying these strict criteria to the existing literature highlights a significant gap in current research. The only eligible direct ICDL outcome study located within the specified date window was conducted by Al-Othman et al. (Al-Othman et al., 2021). Their research examined 27 young participants in Mosul using questionnaires and interviews, ultimately reporting measurable improvements in digital skills and knowledge following ICDL training. Although this study provides recent direct evidence that ICDL-oriented training can successfully support learning, its small sample size, non-Malaysian context, reliance on limited outcome measures and complete absence of an employer-recognition test severely constrain its transferability. Critically, it does not establish whether Malaysian university students would achieve equivalent performance, whether local employers actually understand the credential or whether the certification genuinely influences recruitment outcomes.

Given these limitations in the empirical evidence, the true conceptual value of the ICDL lies in its combination of structured learning and external assessment rather than in the mere recognition of the acronym itself. If its specific modules are carefully mapped to contemporary competence domains and local occupational demands, the ICDL may effectively provide a highly comparable competence signal for graduates. Conversely, if it is delivered merely as an isolated add-on without deep curriculum alignment, authentic tasks, broad employer awareness or accessible student preparation, the resulting credential may hold little more labour-market value than a completely uncontextualized digital badge.

Malaysian higher education and the emerging micro-credential context

Malaysian higher education is actively exploring micro-credentials, although the academic literature guiding this implementation remains emergent. Che Ahmat et al. identify clear opportunities for flexible and employability-oriented educational provision (Che Ahmat et al., 2021). At the same time, they note a limited body of Malaysian scholarship alongside significant challenges regarding precise definitions, professional development and overarching institutional design. Adding to this complex picture, more recent evidence from Malaysian language educators demonstrates generally constructive views of micro-credentials. These educators, however, report continuing difficulties with curricular integration, structural guidance, student support, credit transfer processes and formal recognition (Lip et al., 2025).

Beyond these institutional challenges, the national context also presents a strong demand-side rationale for alternative educational pathways. Tee et al. show that local employers view digital skills as highly relevant to hiring decisions and report a clear willingness to invest in micro-credential development (Tee, Song, et al., 2024; Tee, Wong, et al., 2024). Interestingly, one of their analytical models found that this employer willingness to pay did not directly or indirectly improve actual graduate employability. This specific result highlights the crucial reality that mere employer interest in short credentials does not automatically translate

into tangible employment outcomes for graduates. Reinforcing this perspective, Kee et al. indicate that the actual skills learners acquire and the fundamental quality of the course design remain central to achieving meaningful results (Kee et al., 2023).

Synthesizing this Malaysian evidence therefore reveals a promising yet largely untested proposition. An internationally assessed digital literacy credential might successfully close the critical signaling gap between broad university study and specific employer demands. Nevertheless, its ultimate value will depend heavily on measurable competence gains, demonstrated local relevance, widely recognized assessment methods and deep integration into the academic and career narratives of students. To rigorously evaluate this potential, the present systematic review tests the empirical support for each link in this proposed chain while carefully identifying areas where concrete evidence is still completely absent.

METHODOLOGY

Review design and reporting standard

A systematic literature review was conducted and reported in accordance with PRISMA 2020 guidelines (Page et al., 2021). This review was explicitly designed as an integrative evidence synthesis because the central research question broadly spans educational measurement, higher education policy, employer demand and credential design. To maintain strict focus, the primary unit of inclusion was restricted to English language journal articles. Although the study protocol was fully developed prior to final screening, it was not prospectively registered. Consequently, all eligibility criteria, search strategies, quality appraisals and synthesis decisions are transparently reported below to fully support future replication.

Establishing a clear temporal boundary for this methodology, the evidence window was defined prospectively to include publications from 1 January 2021 through 1 January 2026. This specific end date effectively captures the complete publication period from 2021 to 2025 while intentionally excluding any subsequent evidence from 2026. To ensure comprehensive coverage, the primary search was last updated on 20 August 2026. This final update allowed the review to locate relevant articles that were published online before the strict cut-off date but were indexed later in the academic databases. Finally, to guarantee accessibility and transparency across the study, only articles providing a freely accessible full text or a freely downloadable manuscript were considered eligible for inclusion.

Information sources and search strategy

To minimize databases and regional biases, the search strategy utilized multiple open discoveries and verification routes to locate relevant information sources. Because this review imposed a full text openness criterion, all identified records were carefully traced from their initial discovery interfaces directly to the official publisher, DOI or open repository copies prior to final inclusion. The specific source groups and their corresponding roles in this methodological process are outlined in Table 1.

Table 1: Search-source coverage and function

Source group	ABC	ABC
Global index and metadata routes	Open discovery of journals represented in Scopus/Web of Science ecosystems; Crossref/DOI and journal sites used to verify metadata and article status.	Digital literacy; micro-credentials; employability; Industry 4.0.
International databases/repositories	ERIC; Directory of Open Access Journals; PubMed/PubMed Central; publisher open-access collections; institutional full-text repositories.	Education, interdisciplinary competence, systematic reviews and empirical studies.
Regional and	MyJurnal/MyCite discovery where accessible; UiTM Institutional Repository; Malaysian journal	Malaysia-specific employer, student, educator

Malaysian routes	portals and institutional repositories.	and higher-education evidence.
Backward/forward chaining	Reference lists of included reviews and "cited by" trails, followed by date, language, article-type and full-text checks.	ICDL-specific and bridging studies not retrieved consistently by terminology.

Searches were also separated into paired concepts (for example, "ICDL AND university students", "micro-credentials AND employer recognition", and "digital competence AND Malaysia AND employability") because requiring all four concept groups would omit bridging evidence. British and American spelling variants hyphenated and unhyphenated forms, the former ICDL name, and field-specific terms were used. Records were duplicated by DOI, title and author-year combination. The core search expression was adapted to each interface as shown below:

("international certification of digital literacy" OR ICDL OR "international computer driving licence" OR "digital literacy" OR "digital competence" OR "digital skills") AND ("micro-credential*" OR microcredential* OR "digital badge*" OR certification OR "alternative credential*") AND ("higher education" OR universit* OR undergraduate* OR student*) AND ("Industry 4.0" OR "Fourth Industrial Revolution" OR IR4.0 OR employab* OR "work readiness" OR "digital economy")

Selection process and PRISMA flow

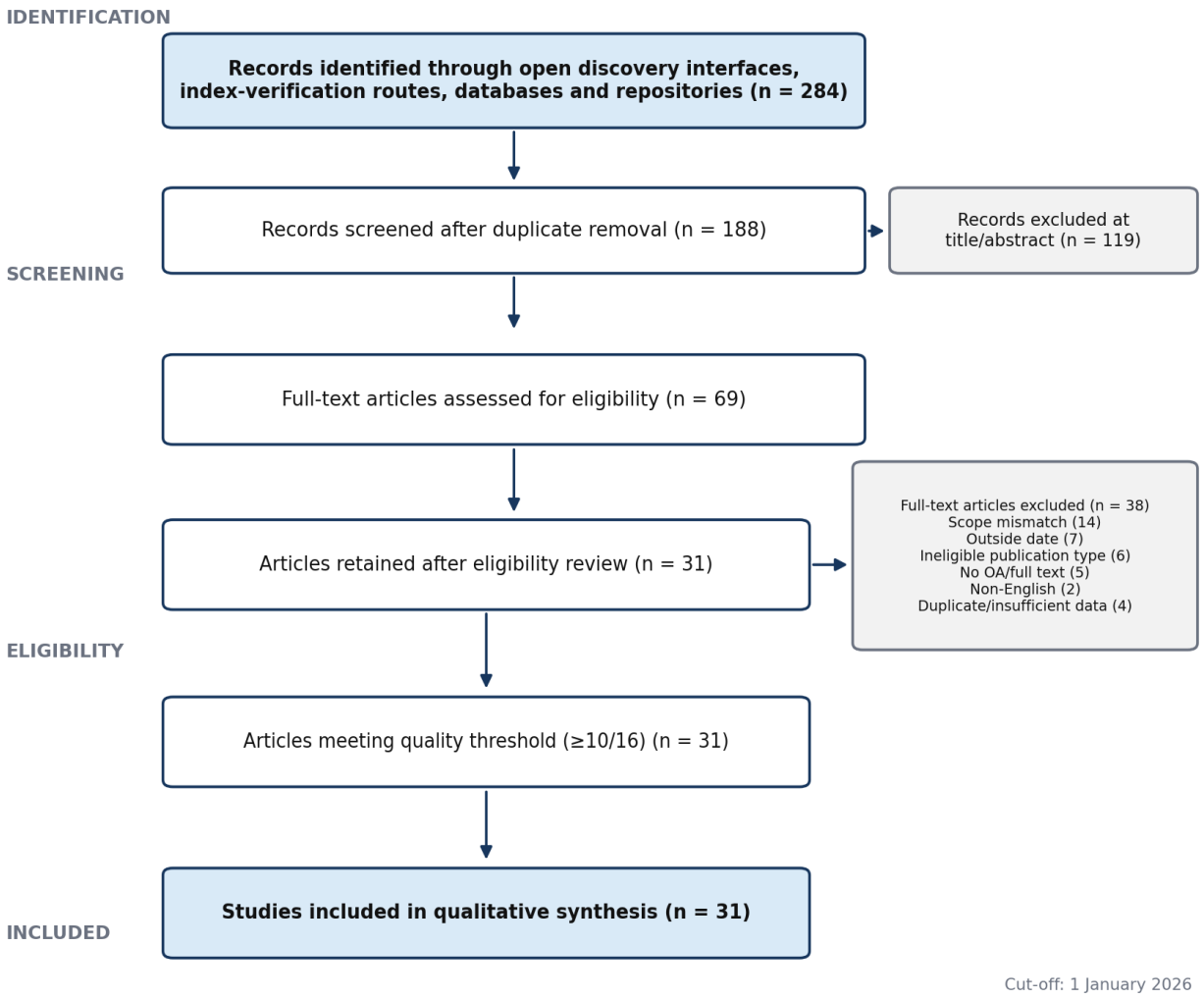
This research establishes strict eligibility criteria to ensure the systematic review relies exclusively on high-quality and highly relevant evidence. By setting specific boundaries around publication dates and language alongside a strict open access requirement, the methodology intentionally filters out outdated, inaccessible or unverifiable information. Restricting the inclusion to peer-reviewed journal articles and systematic reviews guarantees a necessary baseline of academic rigor while deliberately excluding promotional materials and non-empirical reports as shown in Table 2. Furthermore, the targeted criteria regarding the study population and core phenomenon focus the synthesis directly on higher education learners, employers and the precise intersections of digital literacy and employability.

Table 2: Eligibility criteria

Criterion	Included	Excluded
Publication date	Online or issue publication from 1 January 2021 through 1 January 2026, inclusive.	Outside the window.
Publication type	Peer-reviewed journal research article or systematic/integrative review.	Book, chapter, thesis, report, conference paper, editorial, news item or promotional page.
Access	Open-access publisher full text, repository manuscript or freely downloadable full-text link.	Abstract only, paywalled full text or inaccessible copy.
Population /context	Higher-education learners, youth transitioning to work, educators, employers or higher-education institutions.	K–12-only evidence unless it directly evaluated ICDL outcomes relevant to the certification mechanism.
Phenomenon	Digital literacy/competence, ICDL or comparable assessed certification, micro-credentials, Industry 4.0/digital-economy readiness or graduate employability.	Credential technology/security without educational or employment outcomes; generic online learning with no digital-literacy result.
Evidence contribution	Empirical results, systematic synthesis or a substantive conceptual framework that answered at least one review objective.	Descriptive mention without extractable evidence or duplicate version.

The initial open interface search log contained 284 candidate records. After removing 96 duplicate or overlapping versions, the remaining 188 unique titles and abstracts underwent preliminary screening. During this stage, 119 records were excluded for falling clearly outside the topic or publication criteria. This left 69 full texts for a comprehensive assessment. From this group, 38 were excluded for specific reasons such as scope mismatch (n = 14), publication outside the designated window (n = 7) and ineligible publication types (n = 6). Additional exclusions involved papers lacking a freely accessible full text (n = 5), non-English texts (n = 2) and duplicate versions or those with insufficient extractable research evidence (n = 4). Ultimately, 31 articles were retained, all of which successfully met the required quality threshold.

Figure 1: PRISMA 2020 flow of study identification and selection



To achieve these final numbers, a single reviewer conducted the screening process using a rigorous double-pass procedure. During the first pass, titles and abstracts were classified simply as include, exclude or uncertain. In the second pass, all included and uncertain records were meticulously checked against the full eligibility matrix. This crucial step involved reverifying the DOI, publication year, language, article type and the full text access route. Any borderline decisions were resolved conservatively in favor of inclusion at the full text stage, with final exclusion occurring only after a specific and formally documented reason was assigned.

FINDINGS

Characteristics of the included evidence

The final selection included thirty-one articles published between 2021 and 2025. This diverse corpus comprised systematic or integrative reviews, conceptual and policy analyses, quantitative surveys, qualitative and mixed-methods studies and higher-education case studies. Geographical coverage spanned Malaysia, Iraq,

East Africa, Europe, Australia, Latin America, South Asia and various multi-country literature. Thematically, the largest cluster of research addressed micro-credential design, implementation and stakeholder recognition. A second major cluster examined digital competence and employability. Meanwhile, a smaller Malaysian cluster focused specifically on employer demand, youth or student outcomes and educator implementation, with only one article directly examining ICDL training.

This review-level evidence expanded rapidly across the designated period. Demonstrating this growth, Ahsan et al. synthesized 56 studies, Tamoliune et al. retained 32 articles, Varadarajan et al. reviewed 60 studies and Yıldırım et al. synthesized an impressive 205 publications (Ahsan et al., 2023; Tamoliune et al., 2023; Varadarajan et al., 2023; Yıldırım et al., 2025). Together, these reviews documented significant expansion in micro-credential research while also revealing a heavy geographical concentration in the United States, Australia and Europe. Reflecting this regional imbalance, Varadarajan et al. reported only a remarkably small Malaysian contribution within their broader international corpus (Varadarajan et al., 2023).

Beyond these geographical disparities, the evaluated study outcomes themselves were highly heterogeneous. Digital-literacy studies typically measured perceived competence, digital-skill acquisition, academic outcomes or broad employability perceptions. Similarly, micro-credential studies primarily measured user perceptions, design attributes, implementation conditions, stakeholder opportunities and challenges or general recognition. Crucially, direct labour-market outcomes such as actual hiring rates, wage increases, job match quality, time-to-employment and retention were exceedingly rare across the literature. Ultimately, no included study evaluated these concrete employment outcomes specifically for ICDL-certified Malaysian university students.

Digital competence associated with readiness

Across the digital literacy literature, competence was consistently multidimensional. Information and data literacy, communication and collaboration, content creation, safety and problem solving emerged as the most recurrent domains. To measure these areas, Tzafilkou et al. validated a 28-item and six-component student scale with 156 participants (Tzafilkou et al., 2022). Their study found performance differences associated with the field of study, computer experience and age but not gender. Supporting this contextual view, Zhao et al. also found that various personal and educational factors heavily shaped the perceived digital competence of students (Zhao et al., 2021). Furthermore, Vishnu et al. showed that the rapid shift to emergency online learning exposed significant variations in the baseline competence of higher education learners (Vishnu et al., 2022).

Building on these multidimensional domains, the broader employability evidence clearly linked digital competence to workforce readiness but did not establish a uniform effect. For instance, Pažur Aničić et al. found that digital and generic competences both contributed significantly to graduate employability in a national Croatian survey (Pažur Aničić et al., 2023). Similarly, Islam identified a combined Industry 4.0 skill set rather than a purely technical one as essential for modern workers (Islam, 2022). Reinforcing this integrated perspective, Beke and Tick surveyed 147 Hungarian engineering and technical management students (Beke & Tick, 2024). They reported the high salience of problem-based learning, creativity, analytical and critical thinking, communication, technical information technology competence and problem solving.

Although individual studies demonstrate these positive links, broader literature syntheses reveal significant measurement challenges. Caroline et al. synthesized 33 articles focusing specifically on the intersection of digital literacy, employability and innovative work behavior (Caroline et al., 2025). Their review found positive relationships across all these fields but noted the complete absence of a generic business context measure that connected them consistently. Ultimately, this measurement fragmentation limited the direct comparison of effect sizes and prevented the identification of a single digital literacy score that could reliably serve as a universal readiness indicator.

Malaysian demand, gaps and learning outcomes

The Malaysian employer studies provided the most direct demand-side evidence for these digital skill requirements. Tee et al. surveyed 376 employers across the Klang Valley, Johor and Penang (Tee, Wong, et

al., 2024). They found that information and data literacy, digital content creation and problem solving were among the leading areas of demand, with employers reporting significant graduate skill gaps in these domains. A related study by Tee et al., based on 308 employers, identified problem solving and safety as prominent future demands (Tee, Song, et al., 2024). These employers reported that digital skills heavily influenced their hiring decisions and expressed a clear willingness to pay for micro-credentials. However, this willingness to pay did not directly or indirectly predict graduate employability in the tested model. Shifting from employer expectations to the learner experience, Kee et al. surveyed 385 Malaysian youth aged 18 to 22 who participated in the Penang Young Digital Talent Program (Kee et al., 2023). Their findings showed that digital content creation, information and data literacy and problem solving were positively associated with perceived employability. Furthermore, course quality mediated the relationships involving communication and collaboration, digital safety and information and data literacy. This crucial result separated mere program participation from the perceived quality of the learning experience itself.

Supporting this nuanced view of workforce preparation, Khan et al. (2022) linked critical and operational skills, visual and collaborative learning and learning system use directly to digital literacy. Similarly, Rahmat et al. reported that employers viewed social and digital skills as a deeply integrated employability requirement rather than isolated technical abilities (Rahmat et al., 2022). Providing further context from Malaysian community colleges, Wan Mohamad et al. combined 200 surveys with 15 interviews to evaluate online learning dynamics (Wan Mohamad et al., 2025). They found that perceived usefulness and engagement actively predicted learning outcomes, whereas ease of use did not. Their study also noted that internet connectivity and variable prior digital literacy remained evident constraints for students. In response to these complex educational and industry demands, the Malaysian micro-credential implementation studies presented a generally positive but highly qualified outlook. Che Ahmat et al. identified flexibility, targeted professional development and employability signaling as key opportunities (Che Ahmat et al., 2021). At the same time, they recorded significant unresolved issues regarding precise definitions, model design and professional capability. Echoing these mixed sentiments, Lip et al. surveyed 30 language educators at a Malaysian public university (Lip et al., 2025). They found highly constructive perceptions of online micro-credentials alongside persistent challenges involving curricular alignment, guidance, institutional support, credit transfer and formal academic acceptance.

Conditions associated with credible micro-credentials

Across the reviewed literature, five recurring conditions for successful micro-credential implementation were identified. First, the resulting credential claim was significantly stronger when both learning outcomes and assessment criteria were made explicit. Supporting this, Reed et al. showed that faculty design principles directly linked assessment with credential design (Reed et al., 2024). Furthermore, Maina et al. found that an employability-oriented methodology involving 13 lecturers, 169 students and 24 employers greatly improved the visibility, transparency and reliability of the underlying skills evidence (Maina et al., 2022). Second, widespread recognition ultimately depended on clear stakeholder understanding. Varadarajan et al. found recurring employer concerns regarding consistency, academic integrity and formal recognition alongside substantial institutional concerns about providing adequate academic support (Varadarajan et al., 2023). Compounding these issues, Orman et al. identified actual employer recognition as a continuing and significant evidence gap (Orman et al., 2023). Illustrating the complexity of this ecosystem, Farias-Gaytan et al. showed that curriculum design, assessment, accreditation and final recognition were highly interdependent within a Latin American university case study (Farias-Gaytan et al., 2023).

Third, while portability and stackability were highly valued by stakeholders, these features were inconsistently realized in practice. Brown et al., Selvaratnam and Sankey, McGreal and Olcott and Yıldırım et al. collectively identified flexible educational pathways and lifelong learning as the central affordances of these credentials (Brown et al., 2021; McGreal & Olcott, 2022; Selvaratnam & Sankey, 2025; Yıldırım et al., 2025). Despite these structural benefits, problems such as unclear academic levels, variable student workloads, weak credit articulation and inconsistent digital metadata frequently reduced the actual portability of the awards across institutions. Fourth, overall institutional capability significantly affected the success of program implementation. Ahsan et al. identified critical needs for broad stakeholder engagement, enabling digital technology and coherent operational frameworks (Ahsan et al., 2023). Highlighting similar localized

challenges, Lip et al. reported analogous requirements for dedicated educator guidance, robust technical infrastructure and deep curricular integration (Lip et al., 2025). Fifth and finally, broader equity conditions remained a material concern across the educational landscape. Desmarchelier and Cary found that financial costs, technological access and the underlying purpose of the credentialing initiatives ultimately shaped whether flexible educational provision was genuinely just and equitable for all learners (Desmarchelier & Cary, 2022).

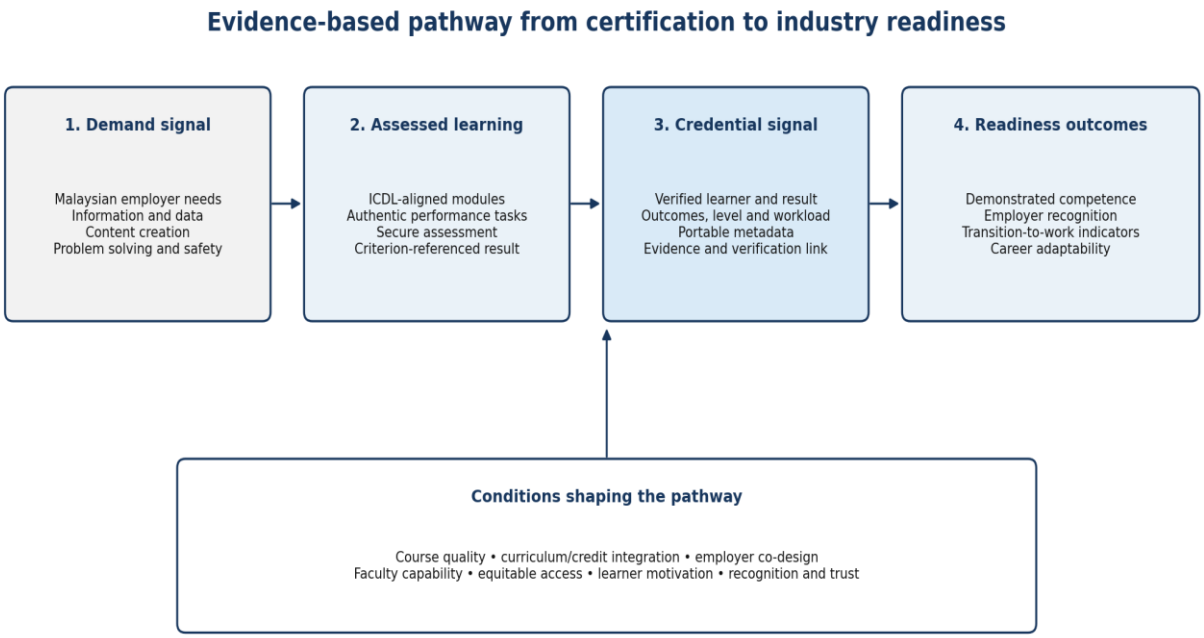
ICDL-specific evidence

Within the eligible 2021 to 2025 corpus, only one article directly evaluated ICDL training. Al-Othman et al. studied 27 young people in Mosul using questionnaires and interviews, ultimately reporting positive development in digital skills and knowledge following ICDL instruction (Al-Othman et al., 2021). While this study successfully supported the learning component of the proposed educational pathway, it did not test a Malaysian population or a specific university curriculum. Furthermore, it lacked a performance comparison against a control group and failed to examine actual employer recognition or subsequent employment outcomes. Highlighting these significant research gaps, no included article compared ICDL certified and non-certified Malaysian university students. Furthermore, no study linked ICDL assessment results to a validated multidomain competence instrument or mapped the certification directly to Malaysian occupational demand. Researchers have also not tested employer interpretation of ICDL metadata or longitudinally followed these specific graduates into employment. Consequently, the direct evidence base for this certification remains substantially smaller than the broader generic evidence bases for both digital literacy and micro-credentials.

Integrated result: the validated digital-readiness pathway

The cross-study synthesis produced a comprehensive four-stage pathway. Stage one begins with a clear demand signal derived directly from Malaysian employer needs. Stage two involves assessed learning within modules that are carefully mapped to relevant competence domains and rigorously evaluated through authentic and secure tasks. Moving to stage three, a formal credential signal identifies the specific learner, the assessed outcomes, the academic level, the expected workload, the issuer, the assessment method and the official verification route. Finally, stage four represents true workforce readiness, which is evidenced through demonstrated competence, active employer recognition, concrete transition to work indicators and long-term career adaptability.

Figure 2: Evidence-based pathway from certification to Industry 4.0 and digital-economy readiness



Connecting these four distinct stages, six critical conditions consistently recurred across the research links. These essential elements include course quality, curriculum and credit integration, employer co-design, faculty capability, equitable educational access and broad stakeholder recognition and trust. Overall, the reviewed evidence directly supported the identified Malaysian employer demands and graduate skill gaps, the established international micro-credential design conditions and the strong associations between digital skills and perceived workforce readiness. Crucially, however, the evidence did not directly support an ICDL-specific effect on actual Malaysian hiring or employment outcomes. Figure 2 visually represents this resulting evidence pattern.

Enhancing University Students' Readiness

This review shows that the case for implementing the ICDL in Malaysian higher education is plausible but highly conditional. The strongest aspect of this case lies in the problem definition. Specifically, employers report a clear demand for multidimensional digital skills alongside observable gaps among recent graduates, whereas university awards often communicate those capabilities only indirectly. Conversely, the weakest aspect of the case is the credential specific outcome evidence. The recent open access literature contains only one small direct ICDL study and completely lacks any Malaysian university evaluation. The most appropriate scholarly conclusion is therefore not that the ICDL has already been proven to improve employability. Instead, its existing assessment infrastructure could be strategically used to test and communicate competence within a carefully designed local educational pathway.

To properly design this local pathway, the synthesis clarifies three critical conceptual distinctions that are frequently blurred in the literature. First, digital experience is not equivalent to actual digital competence. A student's routine use of digital platforms does not demonstrate mature information judgement, secure technical practice or adaptive problem solving. Second, simple course completion is not equivalent to assessed mastery. The true evidential contribution of any certification lies in its valid assessment and traceability. Third, workforce readiness or perceived employability is not equivalent to secured employment. A digital credential can certainly improve the clarity of a candidate's skills without successfully overcoming macroeconomic demand constraints, field mismatches or entrenched recruitment practices.

Addressing these complex distinctions, micro-credential theory helps explain exactly why an international certification may add tangible value. A focused credential can reduce information asymmetry by making a bounded competence claim highly visible and verifiable to external parties. Yet, this signaling function depends entirely on market recognition. If employers do not understand the assessed outcomes, the resulting digital badge may be portable in a technical sense while remaining completely weak in a practical labor market sense. The Malaysian finding that employer willingness to pay for micro-credentials did not predict actual employability strongly reinforces this point. General interest in short learning programs does not substitute for a trusted and established relationship among learning outcomes, strict assessment and real work requirements.

Because market recognition requires trusted evidence, the proposed pathway actively places underlying course quality before surface credential visibility. Kee et al. show that course quality can effectively mediate the relationships between specific skill domains and perceived employability among learners (Kee et al., 2023). Supporting this need for robust design, Maina et al. indicate that credential visibility becomes significantly more useful when the underlying evidence is co-designed with employers and directly connected to student portfolios (Maina et al., 2022). ICDL implementation would therefore be far more academically defensible if its modules were deeply embedded in authentic disciplinary tasks. Examples of this integration include data handling in business courses, digital collaboration in complex project work or cybersecurity judgement in realistic professional scenarios, rather than delivering the program solely as generic software instruction.

By emphasizing these integrated designs, the present findings significantly extend existing Malaysian micro-credential research. This review successfully joins three distinct evidence streams that are usually studied completely separately, namely employer demand, learner competence and credential governance. This comprehensive integration fundamentally reframes the core research question. The primary issue is not simply whether students should receive an international certificate. Rather, the challenge is whether the university can successfully construct and evaluate a valid evidentiary chain spanning from local industry demand to applied

learning, rigorous assessment, trusted evidence and final transition outcomes. That complete chain is empirically testable and finally permits the specific contribution of the ICDL to be clearly separated from general selection effects, student motivation and baseline course design.

CONCLUSION AND RECOMMENDATIONS

Conclusion and contribution

The review synthesised 31 freely accessible English-language journal articles published from 1 January 2021 through 1 January 2026. These sources revealed a consistent need for multidimensional digital competence alongside clear Malaysian evidence of employer demand and graduate skill gaps. Furthermore, international evidence indicated that micro-credentials can successfully make assessed skills more visible and portable. Despite these benefits, the findings also showed that broad recognition is constrained by inconsistent definitions, variable assessment quality, weak credit alignment, poor metadata, a lack of institutional support, equity issues and limited employer understanding. Highlighting a critical gap in this landscape, direct recent evidence on the ICDL itself was exceptionally limited and notably excluded both Malaysian university students and actual employment outcomes.

Responding to these complex findings, the principal contribution of this review is a bounded and evidence-based proposition. The ICDL can plausibly function as a valuable Malaysian higher-education micro-credential only when it represents verified assessed learning that is explicitly mapped to employer-relevant competence, deeply embedded in the curriculum and communicated through trustworthy evidence. By framing the issue this way, the study contributes to ongoing research by clearly separating the learning, assessment, credential and labour-market links rather than simply treating certification as a single standalone intervention. Finally, it contributes to practical application by identifying highly measurable design conditions and transition outcomes for a future Malaysian pilot programme.

Recommendations for policy and practice

To successfully implement this framework, institutions must begin with an employer-validated competence map. Universities should directly compare current ICDL module outcomes with specific Malaysian industry demands in information and data literacy, content creation, safety, communication and collaboration and problem solving. This alignment must also include relevant discipline-specific applications. Once this foundation is established, institutions must strictly treat certification as a measure of assessed learning rather than mere attendance. The final award should clearly disclose the achieved outcomes, the assessment method, the passing standard, the academic level and the expected workload. Furthermore, it must detail the issuer, the identity-verification process and the issue date alongside a secure validation link.

Building upon this transparent assessment, universities must deeply integrate the credential into their broader academic programmes. Practices such as curriculum mapping, offering formal credit or recognized co-curricular status, assigning authentic disciplinary tasks, gathering e-portfolio evidence and providing dedicated academic advising should firmly connect the short credential to the overarching degree. This comprehensive integration prevents the certification from being positioned as an isolated add-on. To ensure this integrated approach holds value in the labour market, universities must co-design credential recognition directly with employers. Employer panels should rigorously review task authenticity and badge metadata. In addition, recruitment teams should be actively tested on their practical interpretation of the credential rather than simply assumed to recognize its actual value.

Alongside these structural and industry partnerships, institutions have a fundamental responsibility to protect equitable student access. Key factors including test preparation, adequate devices, internet connectivity, general accessibility, assessment fees and re-sit support must be carefully monitored. This monitoring should track disparities across socioeconomic backgrounds, disability status, geographic locations, fields of study and prior digital competence. Finally, universities must evaluate the long-term outcomes of these initiatives far beyond basic student satisfaction. At a minimum, this evaluation should track pre-training and post-training performance, overall credential completion, learner confidence, active employer recognition and subsequent

internship performance. Where feasible, future institutional tracking should also measure concrete indicators such as time-to-employment, job match quality, starting wages, career retention and supervisor-rated performance.

Limitations

This review has five notable limitations. First, while the openness criterion improved auditability, it intentionally excluded paywalled evidence and may have introduced availability bias. Second, global index coverage was pursued through open discovery and index verification routes rather than authenticated bulk exports from subscription databases. Consequently, an independent rerun using institutional Scopus and Web of Science accounts might identify additional records. Third, terminology across the literature remains unstable. Some relevant educational programmes may not use the specific term micro-credential, while the cu-

rrent and former names of the ICDL further complicate data retrieval. Fourth, screening and appraisal were completed by a single reviewer using a double-pass procedure, meaning that reviewer error and judgement bias remain possible. Fifth, broad heterogeneity in constructs, samples and outcomes precluded a formal meta-analysis and severely limited any causal inference.

Beyond these methodological constraints, the underlying evidence base itself possesses inherent limitations. Self-report and cross-sectional study designs are highly common across the literature, whereas measurements of actual competence, concrete employer behaviour and longitudinal employment outcomes remain notably rare. Compounding this issue, the single eligible direct ICDL study featured a very small non-Malaysian sample. Therefore, the educational pathway proposed in this paper serves as a synthesis-derived model designed for future testing rather than a definitive estimate of the actual effect of the ICDL within Malaysia.

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