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Micro-Credentialling and the Governance of Legitimacy in Higher Education: An Ecosystem Framework for Digital Credentials



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Micro-Credentialling and the Governance of Legitimacy in Higher Education: An Ecosystem Framework for Digital Credentials

Abstract

Micro-credentials have emerged as a prominent reform initiative in higher education and workforce development, promising flexible, competency-based alternatives to traditional qualifications. Despite rapid expansion, their integration into higher education systems remains uneven, constrained by fragmented governance arrangements, contested institutional recognition, weak employer trust, and limited interoperability across digital credential infrastructures. This article develops an integrated conceptual framework for analysing how micro-credentials are reshaping the governance, legitimacy, and recognition of credentials within higher education systems.

Drawing on an integrative literature review supported by policy analysis and conceptual synthesis, the study examines major international frameworks developed by the European Union, OECD, UNESCO, and the World Wide Web Consortium, alongside interdisciplinary scholarship on competency-based education, qualifications frameworks, labour-market signalling, and digital verification technologies. Particular attention is given to tensions surrounding institutional authority, transnational recognition, employer interpretation of credentials, skills taxonomies, and the marketisation of learning credentials (Jabareen, 2009).

The article proposes a Five-Layer Digital Credential Ecosystem Framework that conceptualises micro-credentialling as a system-level mechanism operating across education systems, modular credential design, digital infrastructure, labour-market signalling, and governance frameworks. The analysis indicates that effective micro-credential integration depends not only on technical verification mechanisms such as verifiable credentials and digital wallets, but on coordinated governance, alignment with qualifications frameworks, and the preservation of institutional legitimacy within higher education. Absent such alignment, micro-credentials risk reinforcing fragmentation and stratification rather than supporting equitable lifelong learning pathways.

The study contributes a higher-education-focused ecosystem framework for understanding how digital credential reforms are reconfiguring credential authority, institutional roles, and recognition practices, offering guidance for universities, policymakers, and regulators navigating the future of credentialling in the digital age.

Keywords: micro-credentialling; higher education governance; digital credentials; credential legitimacy; qualifications frameworks; lifelong learning; labour-market signalling

1. Introduction

The rapid expansion of digital learning, labour-market disruption, and lifelong learning policy has begun to reconfigure how educational achievement, competence, and legitimacy are recognised within higher education systems. Traditional qualifications—such as degrees, diplomas, and transcripts—were developed within relatively stable occupational and institutional arrangements in which higher education functioned as the primary site of knowledge certification and professional legitimacy (Collins, 1979). Within this model, universities and accredited institutions operated as central gatekeepers of recognised competence, while employers interpreted formal qualifications as reliable signals of productivity and occupational readiness (Becker, 1964; Spence, 1973).

Contemporary conditions increasingly challenge these arrangements. Accelerating technological change, automation, platform economies, remote work, and global workforce mobility have intensified demand for continuous upskilling, rapid reskilling, and greater transparency of competencies beyond traditional degree structures (OECD, 2021b; Oliver, 2022). Skills strategies and future-of-work analyses consistently emphasise the need for systems capable of recognising learning across the life course rather than at fixed educational endpoints (OECD, 2019; CEDEFOP, 2020). At the same time, recognition-of-prior-learning scholarship has long questioned the exclusivity of institution-based validation by demonstrating that legitimate competence formation extends well beyond formal educational settings (Harris, 1999; Andersson & Fejes, 2005). Learning now occurs across universities, workplaces, professional communities, digital platforms, and informal social environments, rendering static, institution-bound credential systems increasingly inadequate for representing lifelong competence development.

The COVID-19 period further intensified these structural shifts by normalising large-scale digital delivery and exposing limitations in traditional credential verification practices. Higher education institutions rapidly adapted assessment and certification processes, while employers expanded skills-first hiring strategies in response to shifting competency demands. Platform-based and modular learning models gained widespread legitimacy, highlighting growing misalignments between linear degree pathways and increasingly non-linear patterns of skills acquisition across education and employment systems.

Micro-credentials have emerged as a prominent response to these pressures (Kato et al., 2020; OECD, 2021a; OECD, 2023). Modular, competency-based credentials provide recognition of discrete learning outcomes that can be verified, stacked, and transferred across educational and professional contexts (Oliver, 2019; Selvaratnam & Sankey, 2021;

McGreal & Olcott, 2022). Unlike traditional qualifications that aggregate broad disciplinary learning over extended periods, micro-credentials isolate specific competencies and certify them independently. Such modularity offers learners greater flexibility while enabling higher education systems to respond more directly to labour-market expectations and occupational change.

Parallel developments in digital credential technologies have further reshaped how qualifications are stored, authenticated, and exchanged (Gibson et al., 2015). Digital badges, verifiable credentials, blockchain-supported certification systems, and learner-controlled digital wallets increase portability, reduce verification barriers, and facilitate recognition across institutional and national boundaries (Rossiter & Tynan, 2019; Grech & Camilleri, 2017; Buchem, 2024). Credentials increasingly operate as dynamic, lifelong records of learning rather than as static institutional artefacts tied to singular educational episodes.

Despite this rapid expansion, scholarship on micro-credentials remains conceptually fragmented. Educational research often focuses on competency-based learning and modular curriculum design (Johnstone & Soares, 2014; Gervais, 2016; Buckley & Caple, 2022). Policy literature emphasises lifelong learning, inclusion, and qualification framework reform (Council of the European Union, 2022; Oliver, 2022). Technological studies concentrate on verification infrastructure and digital trust architectures (Sharples & Domingue, 2016; Rossiter & Tynan, 2019), while labour-market research examines signalling dynamics, credential inflation, and employability outcomes (Brown et al., 2011; Tomlinson, 2017; Brown et al., 2020). Higher education scholarship has noted the limited integration of these strands, particularly in relation to how credential systems mediate institutional authority, recognition practices, and social stratification (Marginson, 2016, pp. 81–90, 152–167; Wheelahan, 2015). These bodies of work remain insufficiently integrated, limiting system-level understanding of how credential legitimacy is produced across higher education.

Micro-credentials therefore should not be understood as isolated digital products or

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supplementary certificates, but as connective mechanisms within broader credential ecosystems. Credential value depends not only on educational design, but also on digital verification systems, employer recognition practices, qualification framework alignment, and governance legitimacy (Allais, 2011; Raffe, 2013; Scott, 2014). Absent coordination across these domains, credential expansion risks producing fragmentation rather than improved mobility or transparency.

This article shifts analytical attention from credential form toward ecosystem governance. Rather than asking whether micro-credentials should replace traditional qualifications, the discussion examines how digital credential systems are reconfiguring institutional authority, labour-market trust, and the governance of legitimacy within higher education. A Five-Layer Digital Credential Ecosystem Framework is introduced to explain how education systems, micro-credential design, digital infrastructure, labour-market signalling, and governance mechanisms interact to shape credential legitimacy across the education–workforce continuum.

The central argument advanced is that the effectiveness of micro-credentials depends on coordinated operation across these interdependent layers rather than on credential proliferation alone. Micro-credentials function most productively when positioned as trusted bridges linking higher education, lifelong learning, and workforce mobility. Their significance lies not in displacing degrees, but in reshaping how legitimacy, recognition, and value are produced within contemporary higher education systems.

2. Micro-Credentialling, Non-Formal Learning, and the Governance of Recognition

One of the most consequential challenges facing contemporary higher education concerns the recognition of learning that occurs beyond formal degree programmes. Non-formal and informal learning—acquired through professional practice, workplace training, digital platforms, and self-directed study—has historically remained marginal within degree-centred qualification frameworks. Traditional credentialling systems privileged institutionally delivered curricula and programme-based learning, often leaving substantial bodies of practical, experiential, and workplace-based learning formally unrecognised. This structural exclusion has reinforced the centrality of higher education institutions as gatekeepers of legitimate knowledge while limiting the visibility and value of learning acquired elsewhere.

Micro-credentials have emerged as a response to this recognition gap. By offering targeted, competency-based certification of discrete learning outcomes, micro-credentials create mechanisms for validating learning that occurs across diverse contexts (European Commission, 2020; Oliver, 2022). In contrast to degree programmes that aggregate broad disciplinary learning over extended periods, micro-credentials isolate specific competencies and certify them independently. This capacity to translate non-formal learning into verifiable and portable credentials represents a significant shift in how legitimacy is produced within higher education systems.

The growing importance of non-formal learning is closely linked to labour-market transformation. Workers increasingly acquire relevant competencies through short courses, professional certifications, project-based work, and platform-mediated learning rather than through extended degree pathways alone. Research on recognition of prior learning demonstrates how such trajectories challenge conventional boundaries between education, work, and training, particularly in adult and continuing education systems (Harris, 1999; Andersson & Fejes, 2005; Wheelahan & Moodie, 2018). Micro-credentials convert these learning experiences into legible forms of evidence that can circulate across institutional and occupational contexts, thereby altering the relationship between higher education and the labour market (Werquin, 2010; McGreal & Olcott, 2022; Ahsan et al., 2023).

Flexibility and stackability are central features of micro-credential systems. Micro-credentials are typically designed as short, focused learning units that may be completed independently or accumulated into larger credential structures. Research on modular and stackable credentials highlights their potential to support cumulative learning trajectories aligned with changing professional goals rather than linear, time-bound educational pathways (Buckley & Caple, 2022; Schreurs & Montalvo, 2022). From a higher education perspective, this modularity challenges established assumptions about curriculum coherence, progression, and the temporal organisation of learning.

The implications of micro-credentialling extend beyond efficiency and flexibility to questions of equity, inclusion, and institutional authority. Individuals who lack access to traditional higher education pathways—including career changers, freelance workers, migrants, and learners from marginalised communities—often possess valuable competencies acquired through work and informal learning. Policy analyses of lifelong learning systems emphasise that recognition

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mechanisms play a critical role in widening participation and improving labour-market inclusion, particularly for adult learners (CEDEFOP, 2020). Micro-credentials offer structured pathways for recognising such competencies, potentially lowering barriers to formal validation and mobility.

Despite these promises, integration of non-formal learning into higher education systems remains uneven. Concerns persist regarding the consistency, quality, and comparability of micro-credentials issued by diverse providers across jurisdictions. Comparative studies indicate that weak alignment between assessment standards, qualification frameworks, and institutional recognition practices limits acceptance by both employers and higher education institutions (Oxley & van Rooyen, 2021; CEDEFOP, 2020). These challenges reveal that recognition is not simply a technical or curricular issue, but a governance problem tied to trust, authority, and legitimacy (Suchman, 1995).

Growing attention has therefore been directed toward aligning micro-credentials with national and transnational qualification frameworks. European policy initiatives emphasise alignment with systems such as the European Qualifications Framework to enhance legitimacy and facilitate accumulation and transfer of learning (European Commission, 2021). Comparative analyses suggest that regions with integrated lifelong learning frameworks are better positioned to embed micro-credentials within higher education systems, supporting credit recognition, progression pathways, and interoperability across institutions and borders (OECD, 2019).

Within lifelong learning systems, micro-credentials thus operate as connective instruments linking fragmented learning experiences into coherent competence profiles. Their effectiveness depends on coordinated relationships between higher education institutions, quality assurance mechanisms, digital infrastructure, labour-market recognition practices, and governance frameworks. When embedded within supportive governance arrangements, micro-credentials enable non-formal and informal learning to move from the periphery of credentialing systems toward institutional and labour-market legitimacy. When governance alignment is absent, however, micro-credentials risk amplifying fragmentation rather than strengthening recognition within higher education.

3. Methodology: Integrative Literature Review and Conceptual Synthesis

This study adopts an integrative literature review supported by policy analysis and conceptual synthesis to examine how micro-credentials acquire, sustain, and communicate legitimacy within higher education systems. The review brings together scholarship and policy evidence across educational provision, competency recognition, digital infrastructure, labour-market signalling, and governance to identify areas of convergence, qualification, and tension. The literature examined encompasses research on micro-credentials, competency-based education, qualifications frameworks, recognition of non-formal and informal learning, labour-market signalling, digital credentials, interoperability, and higher education governance. Particular attention is given to international policy and standards frameworks developed by the European Union, OECD, UNESCO, and the World Wide Web Consortium, alongside established scholarship that provides conceptual and analytical foundations for interpreting credential legitimacy, institutional authority, and recognition.

The review was organised around the central problem of how micro-credentials acquire and sustain legitimacy within higher education systems. Sources were therefore interpreted according to their contribution to five interconnected analytical dimensions: (a) educational provision and learning design; (b) micro-credential structure and competency recognition; (c)

digital verification and portability; (d) labour-market signalling and employer recognition; and (e) governance, quality assurance, and qualification-framework alignment. These dimensions correspond to the five layers subsequently developed in the Digital Credential Ecosystem Model.

The analysis proceeded through comparative conceptual synthesis rather than statistical aggregation. Evidence and arguments from different research traditions were examined for areas of convergence, qualification, and tension, with particular attention to the conditions under which micro-credentials may achieve recognition and trust. Policy documents and technical standards were used to contextualise institutional and technological developments, while interdisciplinary scholarship was used to interpret their implications for legitimacy, authority, and credential value.

The resulting framework is an analytical synthesis rather than an empirical test of causal

relationships. The Five-Layer Digital Credential Ecosystem Model integrates existing scholarship and policy evidence to explain how credential legitimacy emerges through interaction among educational institutions, credential design, digital infrastructure, labour-market actors, and governance arrangements.

The methodological scope also establishes an important limitation. Because the study does not report primary empirical data or undertake a formal systematic review with statistical meta-analysis, its conclusions should be understood as theoretically and conceptually grounded interpretations of the available literature and policy evidence. The framework consequently generates propositions for further empirical investigation rather than claims of universal causal effect.

4. Digital Infrastructure, Trust, and the Governance of Credential Legitimacy

Digital infrastructure plays a decisive role in determining whether micro-credentials achieve legitimacy beyond their issuing institutions. Within higher education systems, recognition at scale requires credentialling arrangements that support secure verification, interoperability, and sustained trust across institutional, national, and labour-market contexts. Traditional paper-based certification systems rely heavily on institutional reputation and centralised authority, offering limited portability and weak responsiveness to contemporary patterns of distributed and lifelong learning (Rossiter & Tynan, 2019).

Emerging digital credential infrastructures address these limitations by enabling credentials to function as verifiable and portable records of learning. Technologies such as verifiable digital credentials, blockchain-supported certification systems, and learner-controlled data wallets allow individuals to store, manage, and share evidence of competence across institutional and national boundaries (Buchem, 2024; Rossiter & Tynan, 2019). Standardisation initiatives associated with the World Wide Web Consortium's Verifiable Credentials specifications further support machine-readable authentication and cross-platform interoperability, reducing reliance on manual verification processes (World Wide Web Consortium, 2022). These infrastructures extend the functional reach of credentials beyond issuing institutions, enabling real-time validation by employers, education providers, and regulatory bodies.

However, digital verification alone does not guarantee legitimacy. Trust constitutes a central

concern within digital credential ecosystems, particularly for higher education institutions whose authority rests on claims of academic integrity, assessment validity, and quality assurance. Credential value depends not only on technical security, but on confidence in assessment practices, issuer credibility, and governance arrangements. Technical robustness is insufficient when institutional oversight, shared standards, and accountability mechanisms remain weak or fragmented. Without coordinated governance, digital credential systems risk reproducing—and potentially accelerating—the fragmentation observed in non-digital credential regimes.

Policy initiatives increasingly acknowledge that interoperable infrastructure must be embedded within governance frameworks to sustain trust. European initiatives emphasise standardisation of credential formats, alignment with qualification frameworks, and cross-border compatibility through systems such as the Europass Digital Credential Infrastructure (European Commission, 2021). Comparative analyses indicate that portability and recognition emerge not merely from technical compatibility, but from alignment between infrastructure design, regulatory frameworks, and institutional practice (CEDEFOP, 2020). For higher education systems, this alignment is essential to ensuring that credentials issued in one institutional or national context can be interpreted and trusted elsewhere.

Governance arrangements therefore shape how digital credential systems operate over time. National and transnational regulatory frameworks provide legitimacy by embedding micro-credentials within recognised qualification systems and clarifying their relationship to formal education pathways and labour-market standards. Alignment with national qualifications frameworks and reference systems such as the European Qualifications Framework enhances comparability and supports accumulation and progression across learning pathways (European Commission, 2021). Governance thus functions not merely as oversight, but as a mechanism for integrating credential innovation within existing higher education architectures.

Digital infrastructure also redistributes authority within credentialing systems. Learner-controlled credential storage shifts partial control from issuing institutions to individuals, increasing learner agency over how qualifications are presented and shared. At the same time, decentralisation introduces new responsibilities related to data security, privacy protection, and ethical governance. Research on digital public infrastructure highlights the need to balance individual empowerment with institutional accountability in order to prevent uneven power

shifts and governance gaps (Plantin et al., 2018). For higher education institutions, this balance is particularly sensitive, as institutional legitimacy depends on maintaining public trust while adapting to more decentralised credential ecosystems.

Sustainable digital credential ecosystems therefore depend on coordinated interaction between technological standards, policy frameworks, and institutional practices. Infrastructure alone cannot guarantee recognition or trust. Credential legitimacy emerges through alignment between secure verification systems, transparent governance arrangements, and shared interpretive frameworks used by higher education institutions, employers, and regulators. Digital credentials thus represent a sociotechnical transformation in which technology, policy, and institutional norms co-evolve rather than operate independently.

Table 1 synthesises the core infrastructure and governance conditions required for micro-credentials to function as legitimate components of higher education credential systems, highlighting the institutional risks that arise when these conditions are absent.

Table 1. Governance and Infrastructure Conditions for Micro-Credential Legitimacy in Higher Education

Ecosystem Dimension	Institutional / Governance Requirement	Risk for Higher Education if Absent
Verification	Secure, verifiable credential standards	Erosion of academic credibility and fraud risk
Portability	Interoperable infrastructure across institutions and systems	Credential lock-in and limited learner mobility
Metadata transparency	Clear learning outcomes, assessment criteria, and workload equivalence	Employer and institutional misinterpretation
Quality assurance	Shared review, accreditation, and evaluation mechanisms	Inconsistent academic standards
Framework alignment	Mapping to national and transnational qualification frameworks	Non-recognition within formal HE pathways
Governance oversight	Regulatory coordination and accountability	System-level fragmentation and legitimacy loss

Note. Table entries reflect an ecosystem perspective on credential legitimacy, emphasising institutional trust, governance alignment, and recognition within higher education systems rather than technical adoption alone.

5. Labour-Market Alignment, Career Mobility, and the External Test of Higher Education Legitimacy

A central promise of micro-credentialling lies in its capacity to reshape how learning outcomes produced within and beyond higher education are interpreted in labour-market contexts. As economies become increasingly knowledge-intensive and technologically dynamic, demand has intensified for adaptable, skill-specific competencies that can be acquired and validated within shorter timeframes. Traditional degree structures, while comprehensive, often lack the responsiveness required to keep pace with rapidly evolving occupational requirements (McGreal & Olcott, 2022; Ahsan et al., 2023).

From a higher education perspective, labour-market alignment constitutes more than an employability concern; it functions as an external test of credential legitimacy. Credentials derive social and economic value not solely through institutional issuance, but through their recognition and interpretation by employers. Micro-credentials enable learners to acquire targeted competencies linked to specific job roles, occupational standards, or industry-defined skill needs. This responsiveness is particularly evident in sectors characterised by continuous innovation, where emerging technologies generate new competency requirements faster than traditional curricula can adapt (Buckley & Caple, 2022). By isolating and certifying discrete skills, micro-credentials reduce the temporal gap between learning and employment, strengthening the visibility of applied competence.

Career mobility represents a further domain in which micro-credentials exert influence. Workers transitioning between sectors frequently encounter barriers related to the recognition of prior learning and the transferability of skills. Conventional qualifications may inadequately reflect competencies acquired through professional experience, short-term training, or informal learning. Micro-credentials address this limitation by providing verifiable evidence of specific capabilities, enabling individuals to signal relevance and readiness across diverse occupational contexts (Oxley & van Rooyen, 2021). In this sense, micro-credentials mediate relationships between higher education systems and increasingly fragmented career trajectories.

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Labour-market signalling theory provides a useful lens for understanding this function. Credentials operate as informational signals that reduce uncertainty for employers during recruitment and selection processes (Spence, 1973). Micro-credentials refine signalling precision by making competencies explicit, granular, and contextually meaningful. Empirical research on employer hiring behaviour indicates that employers increasingly attend to skill-level indicators and evidence of applied competence rather than relying exclusively on broad educational proxies (Bills, 2003; Rivera, 2015). Interpretation of credential metadata related to learning outcomes, assessment methods, and proficiency levels therefore supports more informed hiring decisions and improves matching efficiency between workers and job roles (Brown et al., 2011; Tomlinson, 2017; Brown et al., 2020).

Digital credential infrastructures further amplify these dynamics by enhancing the portability and visibility of skills. Learner-controlled data wallets and verifiable digital credentials allow individuals to store and share competency evidence across institutional, sectoral, and national boundaries. Skills become more legible within increasingly fluid labour markets, supporting mobility across organisations and career stages (Rossiter & Tynan, 2019; Buchem, 2024). However, increased informational granularity does not automatically translate into stronger recognition.

Notwithstanding the growing interest, employer recognition of micro-credentials remains uneven. While awareness is increasing, uncertainty persists regarding credential reliability, equivalence, and quality assurance, particularly when credentials are issued by diverse providers operating under varying standards (Ahsan et al., 2023). From an ecosystem perspective, labour-market alignment depends not only on credential availability, but on trust mechanisms embedded within higher education governance, quality assurance regimes, and qualification frameworks. Where such alignment is weak, micro-credentials risk functioning as ambiguous or weak signals rather than as credible indicators of applied competence.

Effective labour-market alignment therefore requires sustained coordination between higher education institutions, employers, industry bodies, and policymakers. Micro-credentials yield the greatest labour-market value when designed in consultation with industry stakeholders, aligned with occupational standards, and embedded within recognised qualification frameworks. Absent such coordination, micro-credentials may increase the volume of credentials without strengthening recognition, thereby intensifying signalling confusion rather than improving transparency.

Within coordinated credential ecosystems, micro-credentials function as connective instruments linking higher education systems to labour-market demand. Their contribution to career mobility lies not in replacing degrees, but in complementing traditional qualifications with flexible, competency-based signals that reflect the realities of contemporary work trajectories. In this sense, labour-market interpretation becomes a critical site where the legitimacy of higher education credential reform is tested and either reinforced or undermined.

6. Systemic and Institutional Challenges to Credential Legitimacy in Higher Education

Growing momentum behind micro-credentialling has not removed the systemic and institutional constraints affecting its integration into higher education. Established credential regimes are deeply embedded within regulatory, financial, and cultural structures that privilege degree-based qualifications as the dominant markers of academic legitimacy. As a result, micro-credentials often encounter resistance from institutions charged with safeguarding academic standards, accreditation integrity, and comparability across programmes (Ahsan et al., 2023; McGreal & Olcott, 2022). These challenges reflect not simple reluctance to innovate, but structural tensions within higher education governance systems.

One of the most persistent challenges concerns academic recognition and equivalence. Higher education institutions operate within long-standing quality assurance frameworks designed around programme-level learning outcomes, credit accumulation, and institutional accountability. Micro-credentials, by contrast, are frequently issued by a diverse range of providers, including universities, private organisations, professional bodies, and online platforms. Variation in assessment practices, credential scope, and instructional design complicates efforts to establish equivalence with existing qualifications, generating uncertainty regarding academic rigour, transferability, and progression within formal education pathways (Moodie & Wheelahan, 2021).

The validation of non-formal and informal learning presents further complexity. While micro-credentials aim to formalise competencies acquired outside conventional degree programmes, institutional mechanisms for recognising such learning remain uneven and resource-intensive. Assessment of experiential learning often requires individualised evaluation, alignment with curricular standards, and expert judgement, placing significant administrative and financial demands on institutions (European Commission, 2021). Comparative studies of recognition

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practices suggest that these demands can discourage systematic adoption, leading to fragmented or selectively applied recognition processes that undermine consistency and trust (Souto-Otero & Villalba-Garcia, 2015).

Quality assurance constitutes another critical constraint. Degree programmes are typically subject to extensive external review and accreditation processes, whereas micro-credentials operate under more heterogeneous oversight arrangements. The absence of shared standards governing learning outcomes, assessment validity, credential volume, and metadata transparency weakens confidence among both employers and higher education institutions (Ahsan et al., 2023; Oxley & van Rooyen, 2021). Governance research indicates that weak or inconsistent quality assurance frameworks frequently limit the scalability of educational innovation, particularly when new credential forms challenge established institutional hierarchies and professional jurisdictions (Capano & Pritoni, 2020).

Institutional inertia further compounds these challenges. Funding models, performance indicators, and regulatory frameworks within higher education remain closely aligned with full programme delivery rather than modular or stackable learning provision. Incentives for adopting micro-credentials may therefore be weak, especially where credential innovation is perceived as peripheral to core academic missions. Analyses of higher education governance suggest that resistance in such contexts reflects structural misalignment between emerging credential models and legacy governance arrangements rather than opposition to innovation itself (Capano & Pritoni, 2020; McGreal & Olcott, 2022).

Fragmentation across jurisdictions introduces an additional layer of complexity. National qualification frameworks, accreditation regimes, and labour-market institutions vary substantially in how micro-credentials are defined, regulated, and recognised. Cross-border portability remains limited where standards diverge or where digital infrastructure interoperability is insufficient. Comparative analyses of transnational qualification systems demonstrate that misalignment between national frameworks continues to constrain recognition of alternative credentials, particularly in cross-border education and labour mobility contexts (Keevy & Chakroun, 2015).

Sustainable integration of micro-credentials therefore depends on systemic coordination rather than isolated institutional adoption. Alignment between quality assurance mechanisms,

qualification frameworks, digital infrastructure, and labour-market recognition practices is essential if micro-credentials are to contribute to coherence rather than complexity within evolving higher education systems. In the absence of such coordination, micro-credential expansion risks reproducing existing hierarchies of legitimacy rather than transforming them.

7. An Integrative Framework for Micro-Credential Systems in Higher Education

The framework developed below integrates the principal dimensions of micro-credential legitimacy identified across educational provision, credential design, digital infrastructure, labour-market signalling, and governance.

Standardisation is a foundational requirement for coherent micro-credential ecosystems. The absence of shared definitions, design principles, and reference points remains a major barrier to adoption across jurisdictions. Variability in learning outcomes, assessment practices, credential volume, and metadata transparency undermines comparability and weakens trust among employers and higher education institutions (Young, 2008; Keevy & Chakroun, 2015). Policy initiatives increasingly emphasise common frameworks to ensure that micro-credentials represent consistent and interpretable units of learning rather than ad hoc certifications (European Commission, 2021; Oliver, 2022).

Portability is a second critical dimension of effective credential ecosystems. In increasingly globalised labour markets, credentials must be transferable across institutions, sectors, and national boundaries. Technical interoperability alone is insufficient without alignment of governance frameworks and recognition practices (CEDEFOP, 2020; OECD, 2019). Digital infrastructures—including interoperable credential platforms, verifiable credential standards, and learner-controlled data wallets—enable secure storage, verification, and sharing of credential information, but their value depends on system-level coordination (Buchem, 2024; Rossiter & Tynan, 2019).

Alignment with qualification frameworks further strengthens credential legitimacy within higher education. Linking micro-credentials to national qualification frameworks and transnational reference systems such as the European Qualifications Framework embeds modular learning within formal education and employment structures. Such alignment supports credit accumulation, progression pathways, and institutional recognition, particularly when alternative

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credentials challenge degree-centred models of authority (Keevy & Chakroun, 2015; Raffe, 2013).

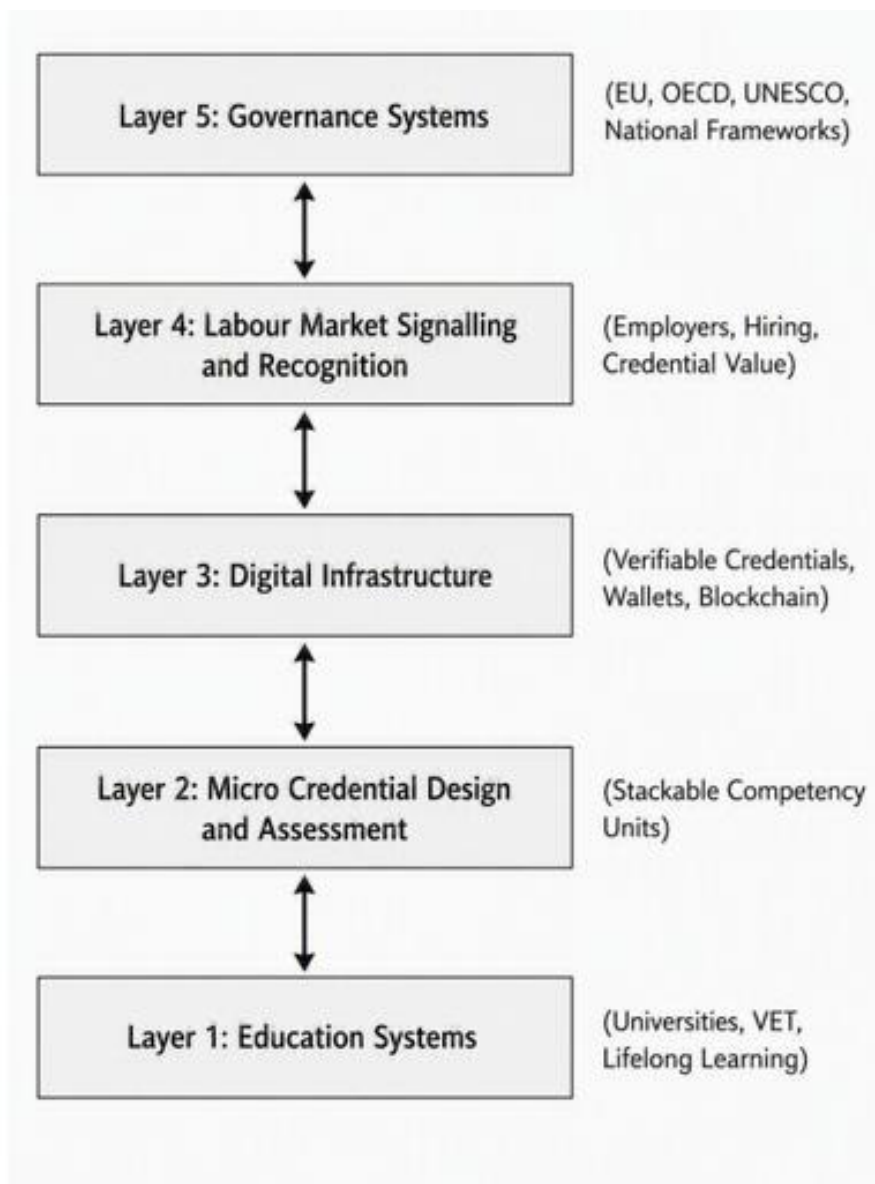
Quality assurance underpins these dimensions. Robust evaluation processes, transparent assessment criteria, and third-party verification contribute to trust across credential ecosystems. Governance scholarship shows that legitimacy in complex systems emerges from layered oversight rather than single institutional authorities (Capano & Pritoni, 2020; Bijker et al., 2012). In higher education, quality assurance therefore requires coordination across providers, regulators, and labour-market actors rather than isolated institutional responsibility.

These conditions support the operation of an integrated, multi-layered credential ecosystem. Formal education provides the foundational layer of structured learning, assessment, and initial validation. Micro-credentials translate learning outcomes from formal, non-formal, and informal contexts into recognisable credentials. Digital infrastructure enables verification, portability, and learner control. Labour-market signalling interprets credential information within employment contexts, while governance and qualification frameworks provide regulatory legitimacy, standardisation, and alignment with national and transnational systems. Credential value therefore emerges through interaction among these layers rather than through linear transmission from education to employment (Brown & Duguid, 2017, pp. 153–160; Plantin et al., 2018).

The five layers define the structural architecture of the ecosystem, while standardisation, portability, qualification-framework alignment, and quality assurance function as cross-cutting conditions through which legitimacy is sustained.

Figure 1 presents the Five-Layer Digital Credential Ecosystem Model, illustrating the interdependence of educational provision, micro-credential design, digital infrastructure, labour-market signalling, and governance in the production of credential legitimacy (Bijker et al., 2012; Capano & Pritoni, 2020). The model illustrates that credential legitimacy emerges through coordinated alignment across multiple layers rather than through credential design or technological adoption alone.

Figure 1. Five-Layer Digital Credential Ecosystem Model



Note. Arrows represent interdependent and reciprocal relationships rather than linear causality, illustrating how micro-credentials derive legitimacy through coordinated interaction between formal education systems, micro-credential design, digital verification infrastructure, labour-market signalling, and governance frameworks. Credential effectiveness depends on alignment across all layers rather than on credential proliferation alone, positioning micro-credentials as translational mechanisms linking lifelong learning with workforce mobility.

Table 2 contrasts traditional and micro-credential systems across key structural dimensions, showing how modular, competency-based recognition reconfigures institutional authority, learner agency, and governance within higher education (Allais, 2011; Wheelahan, 2015). Rather than highlighting differences in credential format alone, the comparison foregrounds divergent assumptions about how learning is recognised, how legitimacy is produced, and how value is assigned within contemporary higher education credential regimes.

Table 2. Comparative Framework: Traditional and Micro-Credential Systems in Higher Education

Dimension	Traditional Credential Systems	Micro-Credential Systems
Curriculum structure	Long-cycle, discipline-based programmes	Short-cycle, modular learning units
Learning pathways	Linear and institution-centred	Non-linear, stackable, lifelong
Assessment focus	Programme-level and summative	Competency-based and outcome-focused
Recognition of non-formal learning	Limited and inconsistently applied	More readily integrated through modular recognition mechanisms
Portability	Institution- and nation-bound	Cross-institutional and transnational
Labour-market signalling	Indirect and proxy-based	Granular and skills-explicit
Governance	Centralised institutional accreditation	Multi-layered ecosystem governance
Learner agency	Low control over credential presentation	High learner control and visibility

Note. Table entries represent an author synthesis informed by prior analyses of micro-credential systems and modular learning frameworks (McGreal & Olcott, 2022; Buckley & Caple, 2022).

The comparison illustrates a structural transition within higher education from institution-centred, time-based credentialling regimes toward more flexible systems oriented around demonstrable competencies and lifelong learning. Traditional credential systems prioritise programme-level coherence, stability, and centralised institutional authority as the primary sources of legitimacy. By contrast, micro-credential systems emphasise modularity, portability, and increased learner agency, while simultaneously redistributing responsibility for recognition across institutions, digital infrastructure, labour-market actors, and governance frameworks. Crucially, the table highlights that this transition entails a shift in how legitimacy is produced—from reliance on credential format and institutional prestige toward multi-layered ecosystem coordination—reinforcing the argument that micro-credentials derive value within higher education not from technical innovation alone, but from systemic alignment across governance, quality assurance, and recognition mechanisms.

8. Implications for Policy, Institutions, and Practice

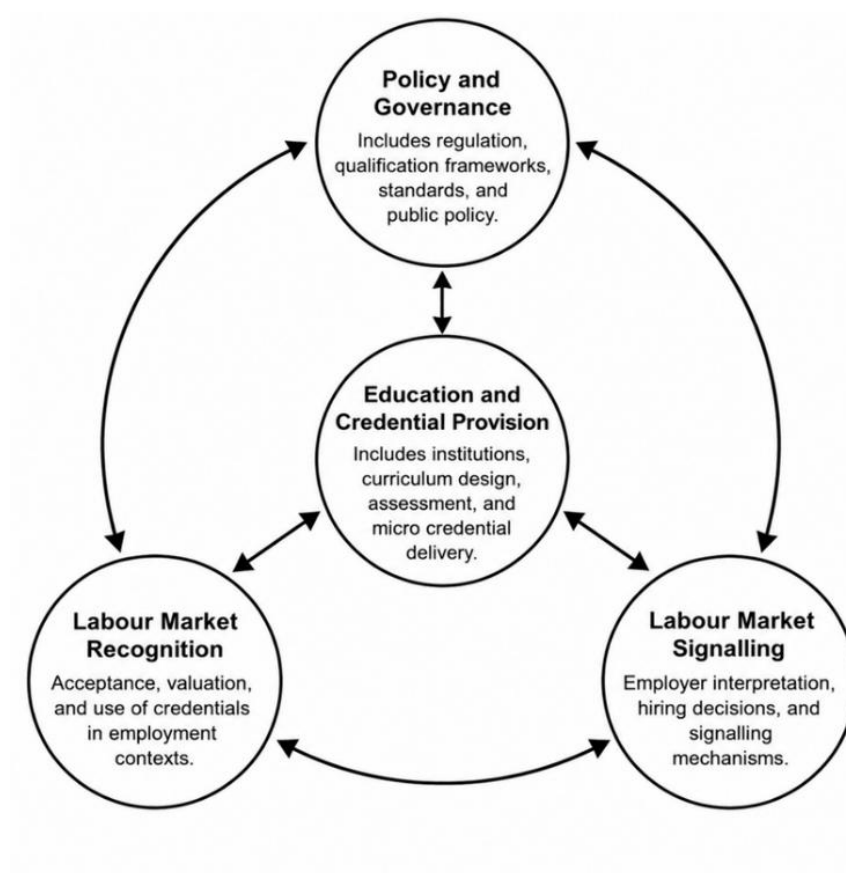
The development of micro-credential ecosystems carries significant implications for policymakers, educational institutions, and labour-market stakeholders. As credentialling systems evolve beyond degree-centric models, governance decisions at national and transnational levels will shape whether micro-credentials function as coherent instruments of recognition or remain fragmented innovations.

For policymakers, the findings underscore the importance of clear definitions, shared standards, and interoperable frameworks for micro-credentials. Alignment with national and transnational qualification frameworks is essential for portability, comparability, and scalability. Policy analyses of skills governance emphasise that regulatory clarity regarding learning outcomes, assessment requirements, and credential volume is critical to sustaining trust across education and employment systems, particularly where alternative credentials challenge established qualification regimes (OECD, 2019; European Commission, 2021).

Without such coordination, micro-credential initiatives risk reinforcing fragmentation rather than improving mobility and inclusion.

Figure 2 illustrates the reciprocal relationships through which policy frameworks, educational provision, labour-market signalling, and recognition shape credential legitimacy.

Figure 2. *Policy–Education–Labour Market Feedback Loop*



Note. Arrows indicate reciprocal influence between policy and governance frameworks, education and credential provision, labour-market signalling, and labour-market recognition processes rather than linear causality.

These feedback relationships show that micro-credential effectiveness depends on continuous interaction rather than one-off implementation: policy frameworks influence institutional design and recognition, while labour-market signalling and recognition feed back into regulatory reform, curriculum adjustment, and credential design. Micro-credential systems therefore require adaptive ecosystem governance rather than static policy intervention.

Educational institutions face parallel challenges and opportunities. Integration of micro-credentials requires re-examination of curriculum design, assessment practices, and credit-recognition policies. Research on institutional responses to modular learning innovations suggests that flexibility in recognising non-formal and informal learning must be balanced carefully with academic rigour and quality assurance to avoid undermining institutional credibility (Marginson, 2016, pp. 18–20, 121–125). Strategic partnerships with digital platforms, professional bodies, and industry stakeholders can support relevance and responsiveness, particularly in rapidly evolving fields, but such partnerships require governance frameworks that align micro-credentials with core educational missions.

Labour-market stakeholders occupy a central position within micro-credential ecosystems. Employers increasingly seek transparent and reliable indicators of applied competence, particularly in contexts characterised by skills shortages and rapid occupational change. Studies of employer engagement with alternative credentials indicate that micro-credentials offer potential improvements in recruitment efficiency by enabling more granular skills signalling, provided that credential standards and assessment practices are perceived as trustworthy (CEDEFOP, 2020). Employer participation in defining competency standards and recognising credential legitimacy therefore remains critical for translating micro-credentials into labour-market value.

Cross-sector collaboration emerges as a critical condition for success. Effective micro-credential ecosystems require sustained dialogue between policymakers, education providers, employers, and quality-assurance bodies. Shared interpretive frameworks reduce uncertainty, while common infrastructure supports recognition across institutional and geographic

boundaries. Fragmented adoption, by contrast, risks producing parallel credential systems with limited signalling value.

From a practical perspective, micro-credentials should be embedded within broader lifelong-learning strategies rather than positioned as standalone products. Hybrid models that combine traditional qualifications with stackable, competency-based credentials offer pathways for balancing academic depth with labour-market relevance (Wheelahan, 2010). Such models support continuous skill development while preserving the integrative role of formal education systems.

Overall, governance choices within higher education will determine whether micro-credentials contribute to structural reform or remain peripheral supplements. Coordinated governance, infrastructure investment, and stakeholder engagement collectively shape the capacity of micro-credentials to enhance transparency, mobility, and inclusion across education and workforce systems.

9. Conclusion and Future Directions

The rapid evolution of digital technologies and labour-market dynamics has challenged traditional models of credentialling. Degree-centred systems, while historically effective under relatively stable occupational conditions, increasingly face difficulties in representing the distributed, non-linear, and lifelong nature of contemporary learning. Micro-credentials have emerged within this context as a significant innovation, offering modular and competency-based recognition of learning across formal, non-formal, and informal settings.

Analysis across education systems, labour markets, digital infrastructure, and governance frameworks suggests that micro-credentials function most effectively as components of coordinated credential ecosystems rather than as standalone credentials. Educational design, verification technologies, employer recognition practices, qualification-framework alignment, and regulatory legitimacy jointly shape credential value. Fragmented implementation across these domains can weaken signalling strength and undermine trust, whereas coordinated integration can enhance transparency, mobility, and inclusion.

The framework developed in this paper advances understanding of micro-credentialling by

shifting analytical attention from credential form to systemic function. Rather than positioning micro-credentials as alternatives to degrees, the analysis situates them as translational mechanisms that connect diverse learning experiences to recognised labour-market signals. Hybrid credential models that combine traditional qualifications with stackable, competency-based credentials offer promising pathways for reconciling academic depth with workforce relevance while maintaining institutional coherence.

From a theoretical perspective, the study contributes to debates on human capital, credential signalling, and lifelong learning by conceptualising credentialing as a multi-layered ecosystem. Institutional authority, digital infrastructure, labour-market interpretation, and governance arrangements emerge as interdependent components of credential legitimacy. An ecosystem perspective provides an analytical lens for examining how trust, recognition, and value are produced and sustained across education–workforce systems, particularly under conditions of accelerating technological and organisational change.

Policy and institutional implications emerge from this systemic framing. Sustainable micro-credential integration requires coordinated governance rather than isolated innovation. Alignment with qualification frameworks, robust quality-assurance mechanisms, interoperable digital infrastructure, and active employer engagement collectively determine whether micro-credentials enhance coherence or contribute to further fragmentation. Institutional reform therefore needs to address incentive structures, accreditation models, and recognition practices alongside technological adoption.

Future research should extend the ecosystem analysis through empirical investigation across national and institutional contexts. Comparative studies examining employer interpretation of micro-credentials, learner outcomes associated with stackable credential pathways, and governance effectiveness within different regulatory regimes would strengthen evidence-based policy development. Longitudinal research tracking how micro-credentials interact with career trajectories over time would further illuminate their role within evolving labour markets. Emerging technologies, including artificial intelligence and advanced data infrastructures, also warrant examination in relation to their potential to reshape verification, trust, and governance within credential ecosystems.

Beyond empirical expansion, continued conceptual refinement remains important. Micro-

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credentials are likely to evolve unevenly across sectors, regions, and institutional settings, shaped by local governance arrangements and labour-market conditions. Attention to these contextual dynamics will be essential for understanding not only whether micro-credentials succeed, but also how and for whom they generate value.

Overall, the future of credentialling lies not in replacing established qualifications, but in constructing integrated systems capable of recognising learning wherever it occurs. When embedded within coherent digital credential ecosystems, micro-credentials offer a viable pathway towards more flexible, transparent, and inclusive models of higher-education governance and workforce development.

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