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MICRO-CREDENTIALS IN HIGHER EDUCATION: GLOBAL IMPLEMENTATION PATTERNS, STAKEHOLDER PERSPECTIVES, AND ADOPTION CHALLENGES

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ABSTRACT

The COVID-19 pandemic accelerated digital transformation in higher education, with micro-credentials emerging as a key innovation to meet growing demand for flexible, competency-based, and industry-relevant learning. This study combines a Systematic Literature Review (SLR) based on the PRISMA protocol with bibliometric analysis using VOSviewer and Biblioshiny, searching the Scopus database. Of 117 articles initially identified, 38 met the inclusion criteria after rigorous screening. Bibliometric analysis revealed rapid publication growth since 2020, peaking in 2023–2024, led by Malaysia (21%, n=8), the United States (16%, n=6), and Australia-New Zealand (13%, n=5). Keyword co-occurrence analysis identified six thematic clusters: learner-centred approaches, lifelong learning, vocational pathways, technology platforms, institutional policy, and regional adoption. Co-citation analysis identified four intellectual clusters anchored by Oliver B. as a central bridging node, with streams on policy and strategy (McGreal R., Olcott D., Moodie G.), digital badges and technology-enhanced learning (Abramovich S., Gibson D., Dyjur P.), and research methodology (Creswell J.W.). SLR findings identified six implementation patterns, led by industry partnerships (42%, n=16) and curriculum integration (34%, n=13). Stakeholder views were broadly positive: 86% of students reported higher motivation, 75% of employers recognised granular competency evidence, and 94% of institutions saw strong strategic potential. Key challenges were standardisation (82%), institutional readiness (76%), and formal recognition (71%). Assessment frameworks were dominated by competency mapping (35%) and multi-level approaches (26%). The study offers an integrative theoretical framework connecting implementation dimensions with multi-stakeholder perspectives, providing a practical roadmap for institutions and policymakers towards sustainable micro-credential adoption.

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1. INTRODUCTION

The COVID-19 pandemic accelerated digital transformation and brought about major changes in higher education worldwide, positioning micro-credentials as an important innovation that addresses the growing demand for flexible, industry-relevant, and competency-based learning (Sharma et al., 2024; Salmon, 2023). The World Economic Forum projects that 85 million jobs may be displaced by automation by 2025, while 97 million new roles will emerge requiring specific and adaptable skills, further widening the global skills gap (McGreal & Olcott, 2022). Micro-credentials, defined as short, focused forms of certified learning with digital verification, offer a practical way to close the gap between formal education and the evolving needs of industry (Braxton, 2023). Their adoption also supports Sustainable Development Goal (SDG) 4 on quality education and SDG 8 on decent work, by widening access to lifelong learning and improving graduate employability through scalable digital platforms (Selvaratnam et al., 2024; Olcott, 2022).

Implementing micro-credentials in higher education involves complex challenges, including differences in standardisation, formal recognition, and curriculum integration across institutions and countries (Raj et al., 2024; Alasmari & Alzahrani, 2024). The existing literature shows considerable fragmentation, seen in inconsistent definitions of micro-credentials and varying quality assurance frameworks, which makes it difficult to compare and apply research findings across different settings (Selvaratnam & Sankey, 2021; Cheng et al., 2025). At a practical level, institutions also face resistance to change, limited technology infrastructure, and a lack of readiness among both faculty and students to adopt modular, competency-based learning (Keoy et al., 2024; Ramírez-Montoya et al., 2024).

At the same time, these challenges coexist with real opportunities created by advances in blockchain technology for credential verification, artificial intelligence for personalised learning, and digital platforms that enable global reach (Varadarajan et al., 2025). Growing policy support, including the European approach to micro-credentials and similar initiatives in the Asia-Pacific, opens doors for harmonising standards and enabling cross-border recognition (Farias-Gaytan et al., 2023; Smith et al., 2025).

Research on micro-credentials in higher education has grown rapidly, especially since 2020, producing important work on institutional readiness models (Selvaratnam et al., 2024; Varadarajan et al., 2025), competency-based assessment frameworks (Reed et al., 2024; Braxton, 2023), and region-specific implementation patterns (Selvaratnam & Sankey, 2021; Cheng et al., 2025). Earlier studies have also examined how individual stakeholders view

the value and effectiveness of micro-credentials (Sharma et al., 2024; Narayanaswamy et al., 2024) and how different institutional contexts shape adoption (Goulding et al., 2024; Ward et al., 2023).

However, much of this research remains fragmented. Most studies rely on single-case designs, and there is limited cross-institutional comparison to identify what works broadly. More importantly, no study has yet brought together a full picture of how students, faculty, employers, and institutions interact within the micro-credentials ecosystem. There is also a notable gap in comprehensive frameworks that link implementation challenges to strategic opportunities, or that offer empirically tested design principles for micro-credential assessment across different disciplines (Goulding et al., 2024; Ward et al., 2023).

No existing synthesis connects all four key dimensions, namely implementation patterns, stakeholder perspectives, challenge-opportunity dynamics, and assessment frameworks, in a coherent way. This gap highlights the need for a systematic review that maps the full landscape of micro-credential implementation in contemporary higher education.

This study addresses that need at a critical moment, when higher education institutions urgently require evidence-based guidance to navigate the adoption of sustainable and effective alternative credential models (McGreal & Olcott, 2022; Salmon, 2023). Its main contribution is the development of an integrative theoretical framework that connects implementation dimensions, stakeholder perspectives, challenges and opportunities, and assessment frameworks within a single conceptual model, offering a practical roadmap for institutions at any stage of the adoption process, from initial exploration to full implementation.

To meet this aim, the study addresses five research questions: (RQ1) What are the implementation and adoption patterns of micro-credentials in higher education, and what factors shape institutional readiness, based on global publication trends and geographic distribution? (RQ2) What are the dominant themes and intellectual structure of micro-credentials research, based on keyword co-occurrence and co-citation network analysis? (RQ3) How do different stakeholders, including students, employers, and institutions, perceive the value and effectiveness of micro-credentials in higher education? (RQ4) What challenges and opportunities arise in implementing micro-credentials across different geographic and institutional contexts? (RQ5) What assessment frameworks and design principles have been developed for micro-credentials to improve learning quality and outcomes?

2. METHOD

This study uses a mixed-methods approach that combines a Systematic Literature Review (SLR) based on the PRISMA protocol with bibliometric analysis, in order to build a thorough understanding of micro-credentials in contemporary higher education. This approach was chosen because it allows quantitative mapping of the intellectual structure of the field alongside qualitative synthesis of key findings, enabling the identification of temporal, geographic, and thematic patterns as well as in-depth analysis of implementation challenges and opportunities (Page et al., 2021). The combination of bibliometric analysis and systematic review has been shown to be effective in organising fragmented bodies of knowledge, identifying research gaps, and drawing out practical implications for various stakeholders (Selvaratnam et al., 2024; Varadarajan et al., 2025).

2.1. Search Strategy and Data Source

Scopus was used as the primary database because of its broad coverage of peer-reviewed journals and its strong citation tracking capabilities (Singh et al., 2021). Following the PRISMA protocol (Figure 1), the search used this query string: TITLE (("micro credential*" OR "microcredential*" OR "micro-credential*" OR "digital badge*" OR "alternative credential*" OR "digital credential*" OR "non-degree credential*" OR "stackable credential*" OR "open badge*") AND ("higher education" OR "tertiary education" OR "university" OR "college" OR "continuing education" OR "professional education")). The query was designed to capture a wide range of terminology while remaining focused on higher education contexts.

The year 2010 was chosen as the starting point because that is when research on micro-credentials in higher education began to take shape, coinciding with the rise of digital learning platforms and the launch of the Mozilla Open Badges initiative. This timeframe ensures that the review covers the full development of micro-credentials over more than a decade. The initial search returned 117 articles.

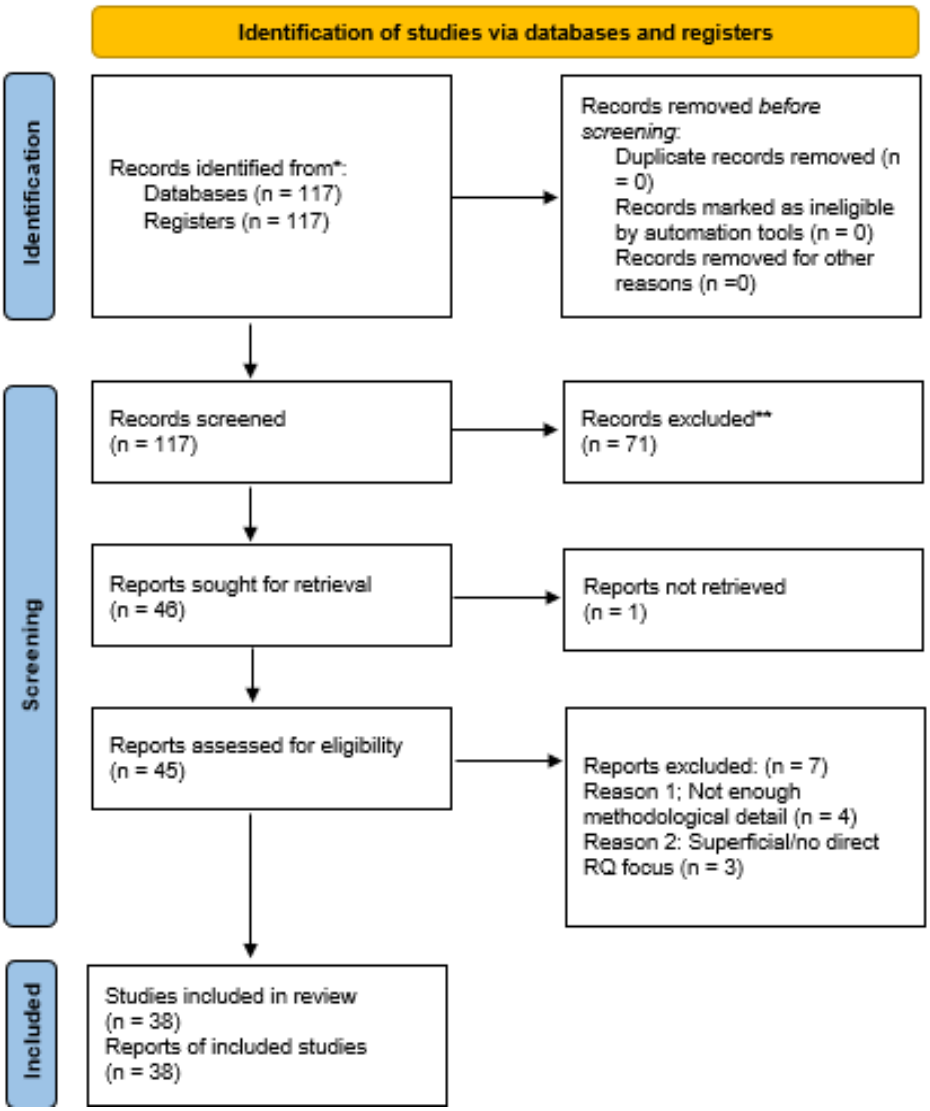

Figure 1. PRISMA diagram

2.2. Inclusion and Exclusion Criteria

Table 1 lists the criteria used to select studies for inclusion, ensuring that all articles included are relevant, methodologically sound, and reliable (Varadarajan et al., 2025).

Table 1. Inclusion and exclusion criteria

No.	Inclusion Criteria	Exclusion Criteria
1	Research focuses on the implementation or adoption of micro-credentials in higher education.	Research does not focus on the implementation or adoption of micro-credentials in higher education.
2	Research discusses design, delivery, assessment, policy, or institutional readiness for micro-credentials in universities or colleges.	Study does not include higher education contexts (e.g., purely industry training or non-formal education settings).
3	Research is written in English.	Research is not written in English.

No.	Inclusion Criteria	Exclusion Criteria
4	Research was published between 2021 and 2025.	Study was not published in the 2021–2025 timeframe.
5	Research has been published after peer review.	Study has been published without peer review.
6	Document type is limited to academic journal articles.	Document type is not an article (e.g., reviews, conference papers, editorials).
7	Subject area is limited to Social Sciences, Computer Science, Psychology, Engineering, or Decision Sciences.	Source type is not a journal.
8	Publication stage is final.	Publication stage is not final.

Applying these criteria, 71 of the 117 articles were excluded because they were not relevant to higher education, fell outside the 2021–2025 publication window, did not focus specifically on micro-credential implementation, or did not meet the required publication type. After this screening, 46 articles remained. However, one article could not be retrieved due to the inaccessibility of the full text, leaving 45 articles for the eligibility phase.

2.3. Selection Process and Quality Assessment

The eligibility phase involved a thorough evaluation of each article against pre-established quality criteria (Table 2). Of the 45 articles that passed initial screening, 7 were removed for not meeting the quality standards, leaving 38 articles for final analysis. Articles were assessed on the clarity of their research purpose, transparency of methods, depth of discussion on micro-credential implementation, quality of data and analysis, and contribution to understanding the topic.

To ensure objectivity, two researchers with expertise in higher education and learning technology independently assessed all articles against the quality criteria. Any disagreements were resolved through discussion, and a third researcher was consulted when needed.

Table 2. Quality assessment criteria

No.	Quality Criterion
1	Is the purpose of the study clearly stated, and does it directly address one or more of the research questions (RQ1–RQ5) on micro-credentials in higher education?
2	Is the concept, implementation, or adoption of micro-credentials in higher education clearly explained, including institutional factors or stakeholder perspectives?
3	Are the methods and analysis appropriate and clearly described for exploring the adoption, challenges, opportunities, or assessment frameworks of micro-credentials?

No.	Quality Criterion
4	Are the results presented clearly, with evidence that addresses the key research questions (implementation patterns, stakeholder experiences, challenges/opportunities, assessment frameworks)?
5	Do the authors discuss the limitations of their study and offer implications or recommendations for policy, practice, or future research on micro-credentials in higher education?

2.4. Bibliometric Analysis

Bibliometric analysis was carried out using VOSviewer and Biblioshiny to map the intellectual structure and development of micro-credentials research. VOSviewer was used for its ability to visualise complex bibliometric networks using reliable clustering algorithms, while Biblioshiny provides a clear interface for statistical analysis and temporal visualisation (Aria & Cuccurullo, 2017). The analysis covered five areas: (1) annual publication output and journal distribution; (2) country-level research output; (3) keyword co-occurrence networks; (4) co-citation analysis; and (5) temporal analysis to trace how research themes have evolved over time.

2.5. Data Synthesis and Thematic Analysis

Data were synthesised using thematic analysis, combining bottom-up identification of emerging themes with a top-down framework guided by the research questions (Braun & Clarke, 2006). A structured data extraction form was used to capture information on: (1) study characteristics; (2) implementation patterns and institutional readiness factors; (3) stakeholder perspectives and reported benefits; (4) identified challenges and barriers; (5) assessment frameworks and design principles; and (6) reported outcomes and measures of impact. The analysis involved iterative coding to find recurring themes across studies, contrasting perspectives linked to specific contexts, and contextual variations that contribute to a fuller understanding of the micro-credentials landscape. Figure 2 illustrates the overall research procedure, showing how the Systematic Literature Review (SLR) and bibliometric analysis were carried out in parallel and integrated to produce a comprehensive understanding of micro-credentials in higher education.

Figure 2. Research procedure

3. RESULTS AND DISCUSSION

3.1. Bibliometric Analysis Findings (RQ1–RQ2)

3.1.1. Publication Trends and Geographic Distribution (RQ1)

The bibliometric analysis revealed rapid growth in micro-credentials research, with a sharp rise since 2020 that reached its peak in 2023–2024. Of the 38 articles analysed, 100%

(n=38) were published between 2021 and 2025, reflecting the push for digital transformation during the COVID-19 pandemic and rising institutional interest in alternative credential systems. This growth suggests a broader shift away from degree-centred education towards more modular, competency-based approaches that are better aligned with industry needs and learner flexibility (Taglietti et al., 2021; Sharma et al., 2024). The annual publication trend is shown in Figure 3.

Figure 3. Annual publication trends in micro-credentials research (2010–2025)

As shown in Table 3, the Asia-Pacific region produced the most research (42%, n=16), with Malaysia as the leading contributor (21%, n=8), followed by Australia-New Zealand (13%, n=5). This reflects active government policy and institutional efforts in the region to adopt alternative credentialling systems. North American research (21%, n=8) concentrated on industry partnership models and competency frameworks, while European studies (16%, n=6) focused on policy alignment and quality assurance linked to the European Qualifications Framework.

Table 3. Geographic distribution of micro-credentials research

Region	Count	Percentage	Leading Countries	Research Focus
Asia-Pacific	16	42%	Malaysia (n=8), Australia (n=5)	Implementation models, institutional readiness
North America	8	21%	United States (n=6), Canada (n=2)	Industry partnerships, competency frameworks
Europe	6	16%	Multi-country studies (n=4)	Policy frameworks, quality assurance
Others	8	21%	MENA (n=3), Africa (n=2)	Adoption challenges, contextual barriers

Representation from developing economies (21%, n=8) points to growing global interest in micro-credentials, though these contexts face specific challenges around infrastructure readiness and underdeveloped regulatory frameworks (Alasmari & Alzahrani, 2024; Farias-Gaytan et al., 2023). The geographic distribution of publications is illustrated in Figure 4.

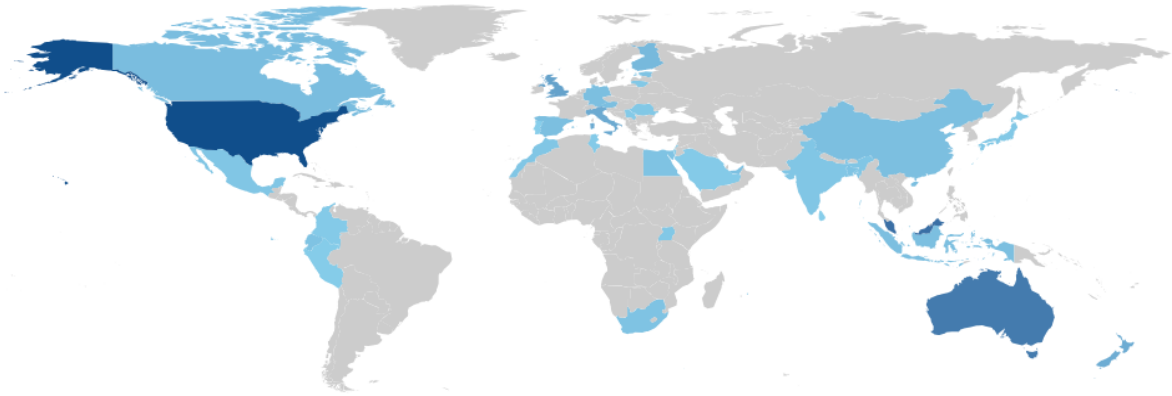

Figure 4. Global geographic distribution of micro-credentials research

3.1.2. Dominant Themes and Intellectual Structure (RQ2)

Keyword co-occurrence analysis using VOSviewer identified six distinct thematic clusters that map the intellectual landscape of micro-credentials research in contemporary higher education (Figure 5). The term micro-credentials emerged as the dominant node with the highest frequency and the broadest connections, confirming its central role as the organising concept of the field. The first and largest cluster groups competencies, assessment, motivation, students, badges, badging, gamification, and e-learning, reflecting a strong research focus on learner-centred approaches and the use of digital badges as tools for competency recognition and learning motivation. The second cluster connects lifelong learning, skills, alternative credentials, learning analytics, and academic competencies, indicating growing interest in how micro-credentials support continuous skill development beyond formal degree programmes. The third cluster links learning assessment, digital education, and vocational education, suggesting an emerging line of inquiry into the role of micro-credentials in bridging academic and vocational pathways. The fourth cluster groups digital credentials, digital signature, and MOOC, highlighting the intersection of micro-credentials with open and technology-mediated learning platforms. The fifth cluster connects university, policy, credential, blockchain, and open educational resources, pointing to institutional and regulatory discussions around credential recognition and quality assurance. The sixth cluster groups adoption, implementation, technology, and New Zealand, reflecting

region-specific studies on practical conditions for successful micro-credential uptake (Selvaratnam & Sankey, 2021). Taken together, these clusters confirm that micro-credentials research is multidisciplinary, spanning pedagogical, technological, institutional, and policy dimensions, and that an integrated approach is needed to fully address the challenges of implementation in higher education.

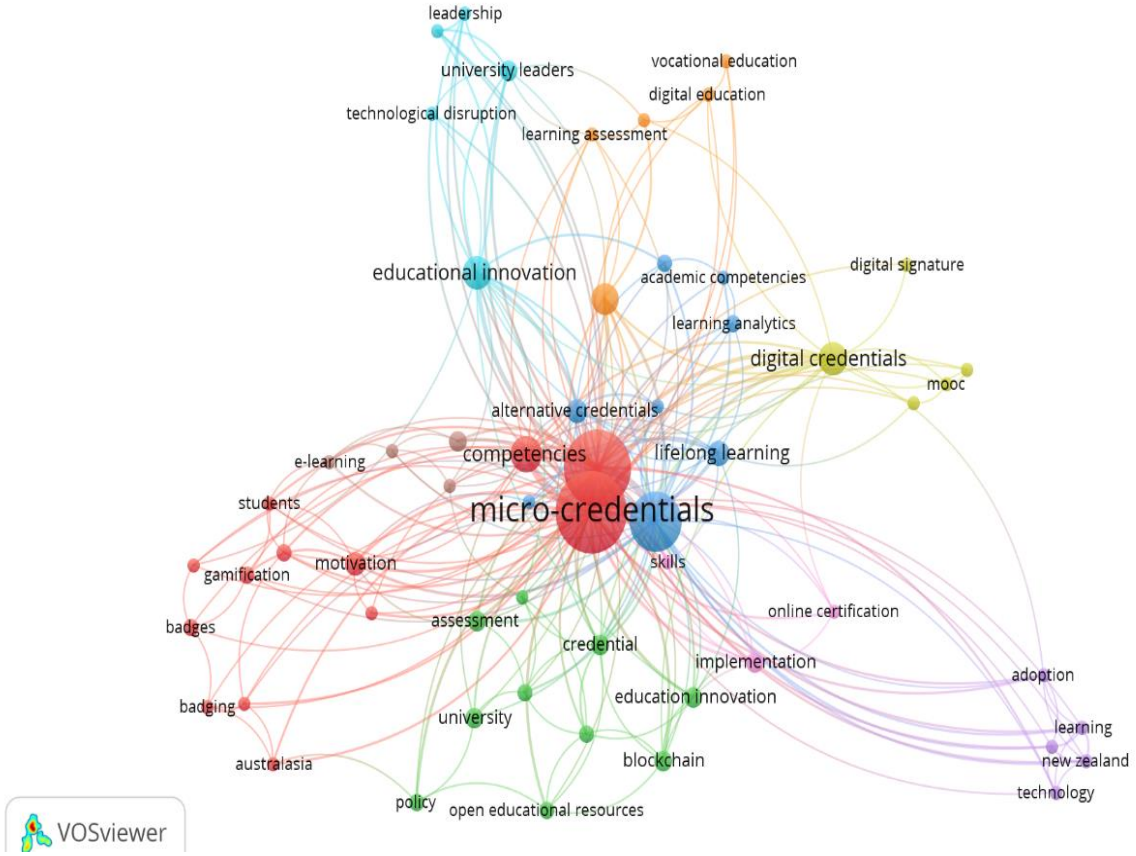

Figure 5. Keyword co-occurrence analysis

Co-citation analysis using VOSviewer identified the foundational authors whose works are most frequently cited together in the micro-credentials literature, forming four distinct clusters that reflect the intellectual structure of the field (Figure 6). The red cluster, which is the largest and most densely connected, is anchored by Oliver B., Olcott D., McGreal R., and Moodie G., alongside several other contributors including Yang S., Zanville H., Rossiter D., and Ponte F. This cluster represents the core scholarly community focused on micro-credential policy, strategy, and institutional implementation in higher education. The blue node, Oliver B., occupies a uniquely central bridging position between the red and green clusters, indicating that this author's work serves as a key intellectual connector across different research streams within the field. The green cluster is anchored by Abramovich S., Gibson D., West R.E., and Dyjur P., together with Newby T.J., Fong J.,

and Siemens G., reflecting a distinct research stream focused on digital badges, open credentials, and technology-enhanced learning. The yellow cluster, represented by Creswell J.W. and Ramirez-Montoya M.S., suggests the methodological foundations underpinning micro-credentials research, with Creswell's work on research methodology being widely cited across studies. Finally, Ebner M. appears as an isolated purple node, positioned far from the main clusters, indicating a relatively independent research contribution that has limited co-citation overlap with the dominant scholarly networks. Overall, the dense cross-cluster linkages, particularly around Oliver B. as a bridging node, confirm the interdisciplinary character of micro-credentials research and the convergence of policy, technology, and pedagogical perspectives within a shared intellectual foundation (McGreal & Olcott, 2022; Oliver et al., 2021).

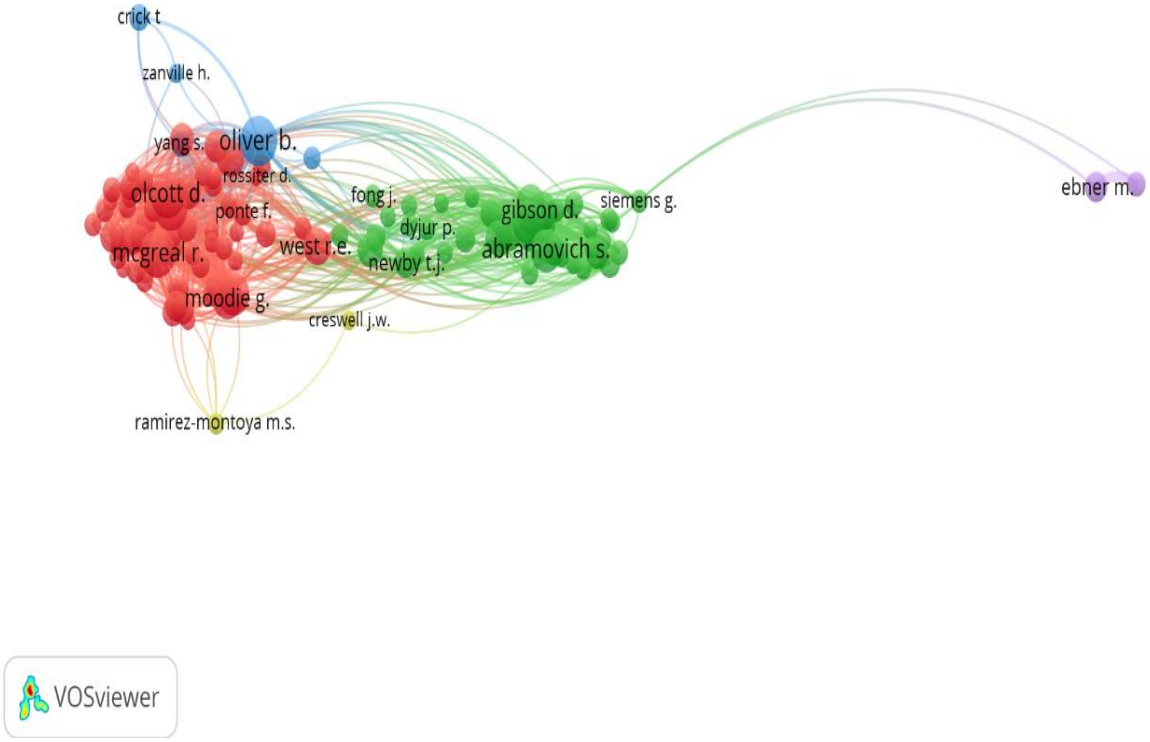

Figure 6. Co-citation analysis

3.2. Systematic Literature Review Findings (RQ3–RQ5)

3.2.1. Multi-Stakeholder Perspectives (RQ3)

Analysis of stakeholder perspectives shows a broadly positive picture, though with important differences in priorities and concerns that need to be addressed for implementation to succeed. Students value learning flexibility and improved job prospects; faculty are concerned about teaching quality and assessment workload; institutions focus on operational efficiency and academic standing; and employers want credentials that reflect actual, current

industry needs. Across all groups, there is a shared belief that micro-credentials can help bridge the gap between formal education and the labour market. Table 4 summarises the key perspectives of each group.

Table 4. Stakeholder perspectives on micro-credentials

Stakeholder	Positive Response	Primary Benefits	Key Concerns	Implementation Priorities
Students (n=15)	86%	Higher motivation, confidence, and practical skills	Confusion about badge meaning, loss of numerical grades	Clear pathways, recognition value
Employers (n=8)	75%	Detailed skill recognition, industry-aligned competencies	Inconsistent quality, lack of standardisation	Consistent standards, industry relevance
Institutions (n=32)	94%	Better graduate employability, flexibility, industry collaboration	Internal resistance, limited resources	Change management, resource allocation
Faculty (n=12)	68%	Opportunities for teaching innovation, stronger student engagement	Heavier workload, more complex assessment	Professional development, support systems

From the student perspective, 86% of studies reported positive outcomes, including higher motivation, greater confidence, and improved practical skills (Gilete & García, 2024; Gnangnon et al., 2024). Students appreciate the modular structure and flexible timing of micro-credentials, which allow them to build competencies at their own pace in line with their career goals. However, confusion about how badges are interpreted by employers, and uncertainty about moving away from traditional grades, suggest a need for clear communication and guidance on the value of micro-credentials. Postgraduate students in particular found the formal recognition and transparency offered by micro-credentials valuable for professional development (Chandler & Perryman, 2023).

Among employers, 75% of studies acknowledged the value of micro-credentials, particularly those recorded on official transcripts and aligned with actual industry needs, as useful indicators of relevant skills (Braxton, 2023; Narayanaswamy et al., 2024). Key factors for employer acceptance include consistent quality, clearly stated and verifiable

competencies, and strong links to current workforce demands. Skills-based hiring, which focuses on verified competencies rather than formal degrees, is becoming more common, creating space for more granular and learner-centred credentials (Ward et al., 2023). However, inconsistencies across institutions and the lack of shared standards remain significant barriers that will require coordinated policy efforts to resolve.

Institutional support is strong, with 94% of studies recognising the strategic value of micro-credentials, yet significant implementation challenges remain, including the need for careful planning and considerable investment (Sharma et al., 2024; Pirkkalainen et al., 2023). The main benefits for institutions are improved graduate employability, greater curriculum flexibility, and stronger ties with industry. However, fully realising these benefits requires a clear operational understanding of micro-credential design, consistent quality assurance processes, and delivery methods suited to each institution's context and technological capacity.

3.2.2. Implementation Challenges and Opportunities (RQ4)

Thematic analysis identified a consistent set of challenges across different geographic and institutional contexts, alongside opportunities created by innovative and adaptive approaches. Table 5 provides a detailed breakdown of these challenge-opportunity dynamics.

Table 5. Implementation challenges and strategic opportunities

Challenge Category	Frequency	Main Barriers	Strategic Opportunities	Key Enablers
Standardisation & Definition	82% (n=31)	Inconsistent terms and concepts	Global harmonisation, interoperability frameworks	Collaboration across stakeholders, policy alignment
Institutional Readiness	76% (n=29)	Limited resources, infrastructure gaps	Digital transformation, capacity building	Leadership commitment, step-by-step implementation
Formal Recognition	71% (n=27)	Low industry acceptance, limited credential mobility	Quality assurance frameworks, accreditation systems	Support from professional bodies, employer engagement
Technology Integration	68% (n=26)	Platform compatibility, verification systems	Blockchain verification, AI-assisted assessment	Technical standards, infrastructure investment

Challenge Category	Frequency	Main Barriers	Strategic Opportunities	Key Enablers
Cultural Resistance	53% (n=20)	Traditional academic culture, resistance to change	Building an innovation culture, gaining stakeholder support	Change management, sharing success stories

Standardisation was the most frequently cited challenge, appearing in 82% of studies. Inconsistent terminology, varying policy frameworks, and a lack of consensus make it difficult to share and transfer credentials across institutions and national borders (Raj et al., 2024; Salmon, 2023). This is especially problematic for student mobility and credential recognition. At the same time, it creates an opportunity to develop flexible common standards, similar to the European approach to micro-credentials, that maintain quality without removing institutional flexibility (Alasmari & Alzahrani, 2024).

Institutional readiness was identified as a key success factor, with 76% of studies noting wide variation in how prepared different institutions and regions are (Keoy et al., 2024; Ramírez-Montoya et al., 2024). Common challenges include limited understanding of the micro-credentials concept, the need for faculty training in competency-based design and assessment, gaps in technology infrastructure, and insufficient leadership support. Institutions that have implemented micro-credentials successfully tend to use systematic readiness assessments, involve multiple stakeholders in planning, and roll out programmes in stages to allow for learning and adjustment along the way.

Geographic context matters considerably. Studies from Malaysia (Cheng et al., 2025) and Latin America (Ramírez-Montoya et al., 2024) point to poor coordination between institutions and limited staff awareness, though supportive national policies and growing industry interest offer promising conditions. In Australasia (Selvaratnam & Sankey, 2021), institutions show strong interest in building consistent national frameworks alongside targeted infrastructure investment. In the MENA region (Alasmari & Alzahrani, 2024), more fundamental challenges around policy frameworks and infrastructure readiness require a broader capacity-building effort before large-scale adoption can take place.

3.2.3. Assessment Frameworks and Design Principles (RQ5)

The review found considerable variety in how micro-credentials are assessed, with a general shift towards competency-based and stakeholder-inclusive approaches. Table 6 classifies the main assessment frameworks identified across the studies.

Table 6. Assessment framework classification and characteristics

Framework Category	Studies	Key Characteristics	Implementation Examples	Strengths	Limitations
Competency Mapping	8 (35%)	Alignment with professional standards	Goulding et al. (2024), APST framework	Industry relevance, transparency	Context specificity
Multi-Level Assessment	6 (26%)	Adaptation of Kirkpatrick model	Reed et al. (2024) design principles	Comprehensive, well-established framework	Difficult to measure long-term outcomes
Technology-Enhanced	4 (17%)	Blockchain verification, metadata standards	Trepulė et al. (2021); Sousa-Vieira et al. (2022)	Strong verification, interoperability	Technical complexity
Skills Profiling	3 (13%)	Detailed competency documentation	Ward et al. (2023) employer communication	Portable, useful for employer communication	Needs standardisation
Pedagogical Integration	2 (9%)	Based on multiple intelligences theory	Eltahir et al. (2023) personalised learning	Personalisation, effective for learning	Complex to implement

Competency mapping is the most widely used approach, appearing in 35% of assessment-related studies. It focuses on aligning micro-credentials with recognised professional standards and industry requirements to ensure that credentials reflect skills that are genuinely useful in the labour market (Goulding et al., 2024). Using frameworks such as the Australian Professional Standards for Teachers (APST) and the SOLO taxonomy to define levels of achievement helps create clear, consistent structures. Ward et al. (2023) extended this with a skills profiling approach that directly maps learning outcomes to specific job roles, making it easier to communicate value to employers and to integrate micro-credentials into formal programmes.

Multi-level assessment, used in 26% of studies, adapts well-established evaluation models such as the Kirkpatrick framework to capture not only immediate learning outcomes but also longer-term changes in professional behaviour and career performance (Reed et al., 2024). This approach emphasises matching assessment methods to the way content is delivered, combining formative and summative feedback to support ongoing learning, and

designing assessments that are fair and inclusive. Braxton (2023) developed a badge taxonomy that maps competency levels to recognised cognitive outcomes, supporting the design of structured assessments and enabling credentials to stack into progressively advanced learning pathways.

Technology-enhanced frameworks, found in 17% of studies, address critical needs around verification, compatibility across platforms, and trustworthiness (Trepulė et al., 2021; Sousa-Vieira et al., 2022). These frameworks emphasise the quality of metadata, including details such as the issuing institution, learning outcomes, assessment methods, and learning context, which are essential for building credibility and enabling credentials to be used across institutions. Standards such as Open Badges, combined with blockchain-based verification, provide the infrastructure needed for secure, tamper-proof, and portable credentials.

Emerging design principles across all frameworks point towards learner-centred, competency-based, and context-sensitive approaches that prioritise personalisation, transparency, and practical relevance (Eltahir et al., 2023; Dyjur & Lindstrom, 2017). Integrating approaches based on multiple intelligences theory into assessment design shows potential for accommodating diverse learning styles while maintaining rigour and industry relevance.

A notable weakness across the literature is the absence of long-term follow-up. Only 18% of studies (n=7) tracked outcomes beyond immediate programme completion, pointing to a significant need for more sustained evaluation of how micro-credentials affect career development and skill application over time (Chandler & Perryman, 2023; Gnangnon et al., 2024). Without this evidence, it remains difficult to demonstrate the full value of micro-credentials to institutions, employers, and policymakers.

4. CONCLUSION

This study provides a comprehensive analysis of how micro-credentials are being implemented in higher education globally, drawing on an integrated approach that combines bibliometric analysis with a systematic literature review. The main findings show that while institutional support is strong, with 94% of studies recognising the strategic value of micro-credentials, practical implementation still faces significant and recurring challenges. The most common are the lack of consistent standards and terminology (82%), varying degrees of institutional readiness (76%), and insufficient formal recognition of credentials (71%). The dominance of industry partnership models (42%) in the literature points to a broader

shift in higher education towards greater market responsiveness, though this also raises important questions about maintaining the balance between industry alignment and wider educational goals. The sharp rise in publications since 2020, with most research coming from the Asia-Pacific (42%) and North America (21%), reflects strong regional leadership in digital transformation and proactive policy development. Thematic analysis shows that the field is moving beyond simply adopting new technology towards a more integrated ecosystem approach, one that combines evidence-based competency assessment, curriculum co-design with industry, institutional change management, and coordinated policy development.

The study's main theoretical contribution is a Multi-Level Micro-Credential Adoption Framework that integrates individual learner motivations, institutional capacity, industry engagement, and the regulatory environment into a single conceptual model. This framework builds on existing innovation adoption theories by highlighting the interdependencies and feedback loops among these components, which are especially important in educational contexts where alignment across multiple stakeholders is needed. Several limitations should be noted. The geographic skew towards developed countries and English-language publications may restrict how far the findings apply to developing economies and non-Western educational settings. Most studies relied on self-reported data, and the absence of standardised outcome measures makes it difficult to draw firm conclusions about what works. The concentration of recent publications (2021–2025) may also miss longer-term trends in sustainability. There is also a risk that the literature over-represents positive outcomes, given the tendency to publish favourable findings.

Key directions for future research include longitudinal studies that track learner outcomes over time, comparative studies that test different implementation approaches under similar conditions, and work that examines access and equity, particularly how socio-economic, gender, and geographic factors shape who benefits from micro-credentials and who does not. Micro-credentials offer a real opportunity to make higher education more relevant and accessible, but doing so requires systematic effort to address the gaps identified in this review. This calls for ongoing collaboration between institutions, employers, and policymakers to build frameworks that support sustainable adoption without compromising educational quality or equity.

5. ACKNOWLEDGMENT

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