



Unveiling Research Trends on Micro-Credentials in ODL: A Combined Bibliometric and Thematic Review

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Abstract

This study presents an in-depth exploration of micro-credentials (MCs) in open and distance learning (ODL) through a combined bibliometric and content analysis of publications from 2015 to 2025, indexed in the Web of Science database. The findings reveal that the USA, Australia, and Germany are among the most influential contributors to the global MC research landscape, with a small number of institutions and authors shaping much of the discourse. MCs—ranging from digital badges to nano degrees—are shown to support lifelong learning, modular education, and personalized skill acquisition. However, the study also identifies critical gaps in the literature, particularly the lack of consistent theoretical frameworks and the limited diversity in research contexts. While mixed methods designs are prevalent, theoretical depth and conceptual clarity are often lacking. By mapping citation networks, co-authorship patterns, and thematic clusters, the study uncovers dominant research trends such as learner motivation, professional development, and flexible learning models. These insights position MCs as a dynamic but unevenly theorized area of educational innovation. The study concludes with practical recommendations for future research, calling for greater interdisciplinary collaboration, inclusion-focused approaches, and broader database integration to better understand and enhance the role of MCs in addressing global educational challenges.

Keywords Bibliometric analysis · Content analysis · Digital certification · Micro-credentials · Open and distance learning

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1 Introduction

The Covid-19 pandemic has significantly increased the demand for Open and Distance Learning (ODL), emphasizing the importance of Micro-Credentials (MCs) as modular and accessible tools for acquiring job-specific skills in today's rapidly changing market (Gauthier, 2020; Hunt et al., 2020). Traditional degree programs no longer meet the needs of the evolving workforce, pushing higher education institutions to adopt ODL and focus on enhancing workforce competencies to address economic challenges (Davidson, 2020; Tamoliune et al., 2023).

MCs are gaining attention in education and business; however, the lack of a universally accepted definition creates barriers to understanding and adoption, particularly among employers (Beirne et al., 2020; Cirlan & Loukkola, 2020; Kato et al., 2020; UNESCO, 2022). This ambiguity limits the effective integration of MCs, even though they offer flexibility by allowing learners to pursue modular and personalized learning paths (Pirkkalainen et al., 2023). Oliver et al. (2019) describe MCs as short, verified educational achievements that can stand alone or contribute to formal qualifications. The MicroHE Consortium similarly defines them as sub-credentials, typically worth at least 5 ECTS, that reflect specific learning outcomes assessed against transparent standards (Shapiro Futures et al., 2020; Varadarajan et al., 2023).

MCs include various formats such as academic and professional certificates, micro-certificates, short courses, MOOCs, nano degrees, digital competencies, micro-masters, alternative competencies, and digital badges (Cirlan & Loukkola, 2020; European Union, 2022; Gallagher, 2018; Malczyk, 2019; Milligan & Kennedy, 2017). These formats share common traits like short learning durations, flexibility, learner-centeredness, and the potential for extended learning (OECD, 2021). Digital badges (DBs) signify digital competencies acquired through mastery of particular knowledge areas (Clayton et al., 2014; Duklas, 2020; Pitt et al., 2018). Introduced at the 2010 Mozilla-sponsored International Open Ed Conference in Barcelona, DBs include metadata about the issuer, criteria, and evidence of achievement (Greene, 2019; Hunt et al., 2020; Noyes et al., 2020). In some studies, the concept of DBs has also been used within the broader framework of MCs.

Even for those unable to pursue traditional education degrees, MCs provide opportunities to acquire in-demand job market skills (Msweli et al., 2022). Validated by higher education institutions, professional associations, or industry partners, MCs enhance their credibility and improve the employability of recipients (Rossiter & Tynan, 2019; Shapiro Futures et al., 2020; Willis et al., 2016). University students particularly value MCs for securing jobs after graduation and advancing their careers (Fisher & Leder, 2022). As flexible and goal-oriented learning tools, MCs align with ODL principles, fostering continuous learning, competence development, and new opportunities in education and employment.

Bibliometric analysis is crucial for assessing the development, current status, and future potential of MCs, revealing their role in addressing ODL's evolving needs. MCs significantly impact areas like educational policies, teaching methodologies, student achievement, and business expectations, supporting personalized learning and professional development. Figure 1 illustrates the growing academic interest in MCs, with a notable rise in publications in recent years. This study combines bibliometric and content analyses to objectively reveal the growth rate, impact levels, and research trends of publications on MCs, alongside an in-depth exploration of key themes and concepts. This dual approach offers strategic



Fig. 1 Number of publications about MCs by year

and practical insights into how MCs are transforming ODL and optimizing their integration into future ODL systems. By identifying the role and impact of MCs, this study contributes significantly to the literature, serving as a valuable reference for educators, policymakers, and researchers.

This study aims to capture the MC research landscape in ODL through a comprehensive bibliometric and content analysis, focusing on articles from the globally recognized WoS database for its high-quality publications (Özdemir et al., 2023; Yavuz et al., 2021). Focusing specifically on MC within ODL contexts, this study aims at addressing the following research questions (RQ):

- What are the dynamics and trends in publications on MCs within the context of ODL in bibliometric terms, including leading countries, institutions, journals, authors, and outstanding keywords?
- How does thematic prevalence manifest within the MCs research community in the domains of ODL, including theoretical/conceptual frameworks, research methods and design, sample characteristics, and data collection tools?

2 Research Background

In recent years, several systematic literature reviews have explored the conceptualization, implementation, and impact of MCs. Table 1 provides a comparative summary of these reviews, highlighting research scope, publication sources (indexed databases), timelines, and key findings.

The systematic reviews in Table 1, covering MCs and DBs, highlight their growing role in higher education and professional development. MCs are recognized as adaptable, skill-specific tools to address job market demands, while DBs enhance competency-based education models. Common themes include the need for robust frameworks, emerging technologies like blockchain, and empirical research for validation. When these reviews are considered

Table 1 Comparative summary of the review studies in literature

Author(s)	Aim of the study	NP	Databases used	PYR	Highlights
Cartis et al. (2023)	To conceptualize MCs within higher education	68	Scopus, WoS	2014–2022	Emphasizes the need for a more transparent and operational conceptual framework and suggests MCs can significantly contribute to curricular innovation
Rajabalee et al. (2023)	To understand the implementation and recognition of MCs in education and professional contexts	38	Science Direct, Emerald Insight, Google Scholar, Scopus, IEEE, Taylor & Francis	2012–2022	Points to a global interest in MCs and their role in acquiring skills quickly, highlighting the peak in research interest in 2021
Tamolilune et al. (2023)	To explore the potential of MCs in post-pandemic recovery through innovations	32	EBSCO, Taylor & Francis, SpringerLink	2015–2022	Notes a diverse geographic distribution of publications and an increase in publications related to MCs during the COVID-19 pandemic
Msweli et al. (2022)	To synthesize research and practice reports on MCs	32	IEEE Xplore, Scopus, Science Direct, Google Scholar, ACM Digital Library	2011–2020	Discusses the multidisciplinary nature of MCs and their impact on lifelong learning and professional development
Selvaratnam and Sankey (2020)	To provide an overview of micro-credentialing practice and synthesize research into a conceptual model	-	Internet search	2016–2019	Highlights the limited focus on MCs in academic research, stressing the need for empirical research on their technical implementation
Varadarajan et al. (2023)	To understand current conceptions and discourses of MCs in higher education	60	Scopus, ProQuest, ERIC, WoS, EBSCO	2015–2022	Emphasizes the need for MCs to meet the requirements of stakeholders and the significant increase in micro-credential research post-2019
Ahsan et al. (2023)	To investigate research trends and the implementation of MCs in higher education	56	Scopus, Google Scholar	2015–2021	Highlights the momentum of micro-credential research in higher education starting in 2017 and suggests focusing on market needs and assessment
Wolz et al. (2021)	To assess the state of digital credentials in higher education institutions	147	Scopus, EBSCO, ACM Digital Library, ScienceDirect, IEEE Explore, AISel	-2019	Reveals an increasing interest in digital credentials and identifies a research gap in shared knowledge for their implementation
Alsobhi et al. (2023)	To review blockchain-based micro-credentialing systems in higher education and identify research gaps	18	IEEE Xplore, SpringerLink, ProQuest, ScienceDirect, Scopus, WoS, Google Scholar	2016–2022	Indicates a significant interest in blockchain-based systems for managing MCs and the need for developing a framework in higher education

Table 1 (continued)

Author(s)	Aim of the study	NP	Databases used	PYR	Highlights
Ha et al. (2023)	To examine literature on the characteristics, awareness, benefits, challenges, and effectiveness of MCs	29	Scopus, Google Scholar, ProQuest	2012–2022	Points out the growing research interest in MCs and the predominant use of quantitative methodology in studies
Noyes et al. (2020)	A systematic review of DBs in health care education	30	MEDLINE, WoS, ScienceDirect, CAB Abstracts	2008–2019	Notes the significant need for further research on the design, implementation, and effectiveness of DBs in healthcare education within competency-based models
Liyana-gunawardena and Scalzavara (2017)	Open badges: a systematic review of peer-reviewed Published literature (2011–2015)		Scopus, WoS, Google Scholar	2011–2015	Highlights the limited empirical evidence on the design and effectiveness of open badges, emphasizing the importance of customized badge systems for different student groups
Li & Fryer (2024)	The Use of Badges in Education: A Systematic Review	32	EBSCO, ERIC, PsycINFO, WoS, Scopus	2013–2022	Points out the gap in understanding the effectiveness of DBs in varied designs and among different populations, with most studies conducted in higher education and of short duration
Motheeram et al. (2018)	A scoping review of digital open badge ecosystems in relation to resource-constrained environments	41	EBSCO, ERIC	2011–2016	Indicates that Mozilla's digital open badges are reimagining accreditation by accurately recognizing competencies and achievements in various learning contexts, particularly aiding resource-constrained environments
Roy and Clark (2019)	DBs, do they live up to the hype?	23	EBSCO, ERIC, IEEE Explore, Scopus, Google Scholar	–	Reveals that DBs generally enhance learning and student engagement, but their effectiveness varies across studies, underscoring the need for more comprehensive research across diverse educational disciplines
Johan et al. (2025)	To review and map micro-credential research in higher education via bibliometrics	85	Scopus	2015–2023	Focus on higher education; performance & science-mapping with VOS-viewer; reports US–AU–CA as leading countries; notes low co-authorship/collaboration and rising output
Narong (2025)	To analyse research trends using keyword co-occurrence and science mapping	401	Scopus	2014–2024	Broad, cross-disciplinary scope; descriptive statistics + co-word analysis + science mapping; identifies frontier topics (digital credentials, blockchain, competency-based education) and post-COVID surge
Yüksel (2025)	To reveal trends in micro-credential studies in higher education using bibliometrics	85	WoS	2015–2025	WoS-only set; keyword co-occurrence yields clusters (employability, skills/learning, distance learning, digitalisation/technology, QA & sustainability); highlights US–AU–CA leadership

together, several methodological and contextual patterns emerge. First, many reviews are primarily conceptual or descriptive in scope—for example, Cartis et al. (2023) emphasize the need for clearer conceptual frameworks, while Selvaratnam and Sankey (2020) synthesize practices into models without bibliometric evidence. Second, a group of studies concentrate on specific technologies or subdomains, such as Alsobhi et al. (2023) focusing on blockchain-based systems, or Noyes et al. (2019) and Li & Fryer (2024) narrowing the lens to digital badges in healthcare or education more broadly. Third, several reviews adopt bibliometric approaches but remain confined to particular datasets or sectors: Ahsan et al. (2023) and Varadarajan et al. (2023) limit their analyses to higher education, while Johan (2025), Narong (2025), and Yüksel (2025) conduct larger-scale bibliometric mappings that nevertheless exclude in-depth content analysis and largely remain tied to Scopus or WoS. Fourth, a number of works highlight geographic or temporal shifts—Rajabalee et al. (2023) and Tamoliune et al. (2023) stress the global surge in MC publications during and after the COVID-19 pandemic, whereas Wolz et al. (2021) and Motheeram et al. (2018) underline institutional or contextual adoption barriers.

Against this diverse but fragmented backdrop, our study advances the literature in three distinct ways. It not only integrates bibliometric mapping with thematic and content analyses but also directs its lens specifically to the ODL context, which remains underexplored in prior reviews. In doing so, it moves beyond descriptive patterns to interrogate theoretical frameworks, methodological approaches, and contextual practices. Furthermore, it contributes a structured identification of research gaps and future directions along three axes—methodological insights, theoretical maturity, and cross-domain adaptability—thus positioning itself as a comprehensive and integrative extension of existing reviews.

3 Research Design

This study employs a comprehensive bibliometric and content analysis approach, recognized as an effective method for systematically examining academic fields to reveal trends, patterns, and emerging themes. The methodological framework focuses on both the quantitative growth of publications on MCs in ODL and the qualitative exploration of their thematic content, providing an in-depth understanding of the field.

3.1 Procedures

The study incorporated the studies indexed in the WoS database. Although Scopus is also a widely recognized and comprehensive database, WoS was preferred due to its higher selectivity, rigorous indexing standards, and broader coverage of high-impact journals. WoS has become a respected and extensive research platform that covers a wide range of topics. In particular, it offers advanced citation tracking and visualization options, making it more suitable for in-depth bibliometric analysis—one of the key approaches employed in this study. Using this dataset gives a strong methodological framework for especially quantitatively analyzing academic literature on MCs, with a focus on ODL.

An essential consideration in bibliometric analyses is the robustness of the inclusion and exclusion criteria for the publications to analyze. We made sure that relevant criteria are well-defined. Figure 2 illustrates the data collection process and the main search terms

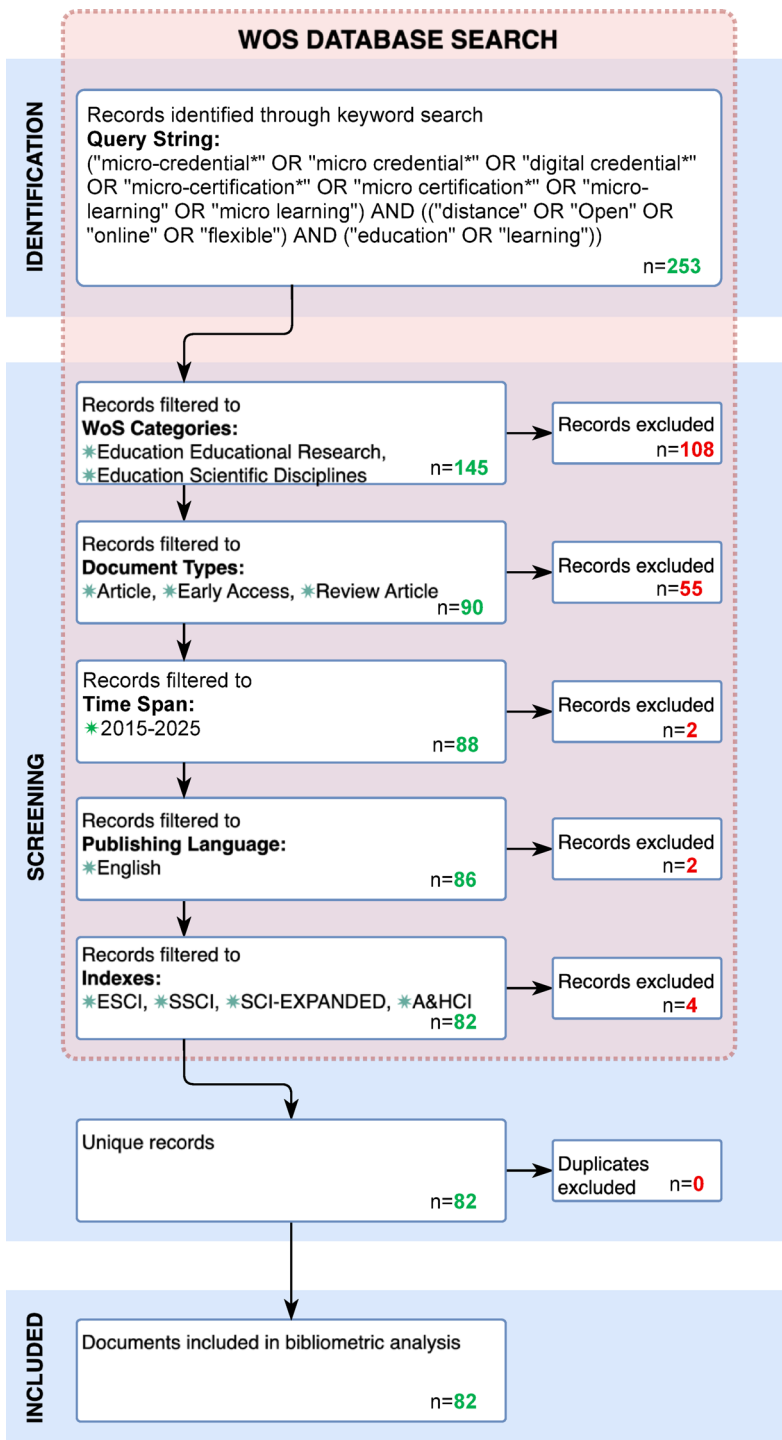


Fig. 2 PRISMA flowchart for outlining the procedures of the bibliometric analysis in this study

identified through a comprehensive search of bibliometric analyses and systematic reviews in the field of MCs in ODL based on the PRISMA methodology. We created a pool of keywords from the reviews we examined and selected the most logical and relevant terms suitable for the scope of our study. These terms cover a wide range of concepts and tools related to MCs, credentials, certificates, etc., which we believe cover most, if not all, of the literature. In this way, a sound framework for retrieving useful publications from the specified databases was established.

As shown in Fig. 2, our initial search revealed 253 publications through the WoS database. The elimination process continued and, ended up with 82 publications encompassing the publications relevant to our interest.

The procedures described so far provide information about the preparation of research for bibliometrics. The remainder of the study involved content analysis. However, this study is not a stand-alone content analysis but rather a combined bibliometric and content analysis. Therefore, conducting content analysis on all retrieved publications was not feasible. Instead, a purposeful selection strategy was employed to analyze the theoretical and thematic characteristics of the most influential studies in the field.

Based on the fact that the older the publication, the greater the potential to be cited, we not only identified the most cited publications overall, but also handpicked the most cited publications from each publication year to give more weight to recent publications that would otherwise be under sampled (Tahamtan et al., 2016). Since no articles were available from 2016 and only one from 2017, 19 that had been cited most frequently in all databases by other researchers were identified (listed in Appendix 1) and analyzed for content. In this way, the most recent trends were also represented in the present study.

3.2 Data Analysis

This study adopted a mixed analytical approach by combining bibliometric and content analysis to provide a comprehensive understanding of research on micro-credentials. Bibliometric analysis focused on publication patterns, key contributors, collaboration networks, citation impact, and keyword relationships. Content analysis explored thematic depth and conceptual directions within the selected literature.

To enhance analytical rigor, VOSviewer and R-Studio were used in tandem. VOSviewer supported the construction of co-authorship, citation, co-citation, and keyword co-occurrence networks, enabling visualization of structural patterns in the field. R-Studio was particularly useful in the thematic mapping process, offering more advanced statistical processing and flexible graphical outputs.

The joint use of these tools contributed to a richer interpretation of the intellectual and thematic development of the micro-credential research landscape, enabling identification of influential clusters, research trends, and potential gaps for future exploration.

The data drawn from the database were analyzed using both VOSviewer and R-Studio to generate illustrative graphs through four different analysis networks:

- 1) Investigating collaborations between authors and countries in the field of MCs, **co-authorship analysis** illuminated the dynamics of collaborative efforts within this specific domain.

- 2) Using **citation analysis**, this study focused on identifying the most referenced journals in the field of MCs in ODL, providing insights into the key sources that contribute significantly to the scholarly conversation.
- 3) By identifying influential research relationships, the **co-citation analysis** identified frequently co-cited studies in the field of MCs, providing a nuanced understanding of the interconnectedness of influential research within this specialized field.
- 4) **Co-occurrence analysis** meticulously selected and classified keywords from relevant articles to visually represent the most prevalent themes and their interrelationships in the context of MCs in ODL.

The findings from these four analyses are detailed in the Results and Analysis Section. For content analysis, one researcher developed a coding scheme based on initial readings, following Erlingsson and Brysiewicz (2017). Three researchers independently evaluated the articles, recording observations in separate tables according to the scheme. After comparing these tables and re-evaluating the articles, the inter-rater reliability for the second coding round was calculated as $\kappa = .937$, indicating a 'very good' level of agreement (Altman, 1990). Consensus on all findings finalized the content analysis. Themes were grouped into overarching categories, shaping the framework for findings and discussion.

4 Results and Analysis

The following sections present the findings from the bibliometric and content analysis of articles retrieved from the WoS database. Each section is titled accordingly to address the specific research questions investigated in this study.

4.1 Bibliometric Analysis

4.1.1 Main Information About the Data

The dataset includes 82 articles published between 2015 and 2025 across 52 different journals. The annual publication growth rate was calculated as 14.87%, indicating increasing scholarly interest in micro-credentials over the last decade. A total of 277 authors contributed to the dataset, with an average of 3.61 co-authors per article. Only 6 articles (7.3%) were single authored, reflecting a predominantly collaborative authorship pattern. Additionally, 23.17% of the publications involved international co-authorship, pointing to growing global engagement in the field. Despite the relatively recent emergence of the topic (average document age: 2.84 years), the articles received an average of 10.61 citations, suggesting strong academic visibility.

4.1.2 Leading Contributors: Countries and Institutions

Figure 3 presents the distribution of author affiliations by country, based on data retrieved from the WoS database. The United States leads with 71 affiliations, followed by Australia (22) and the United Kingdom (16), indicating strong research activity from English-speaking countries in the field of micro-credentials.

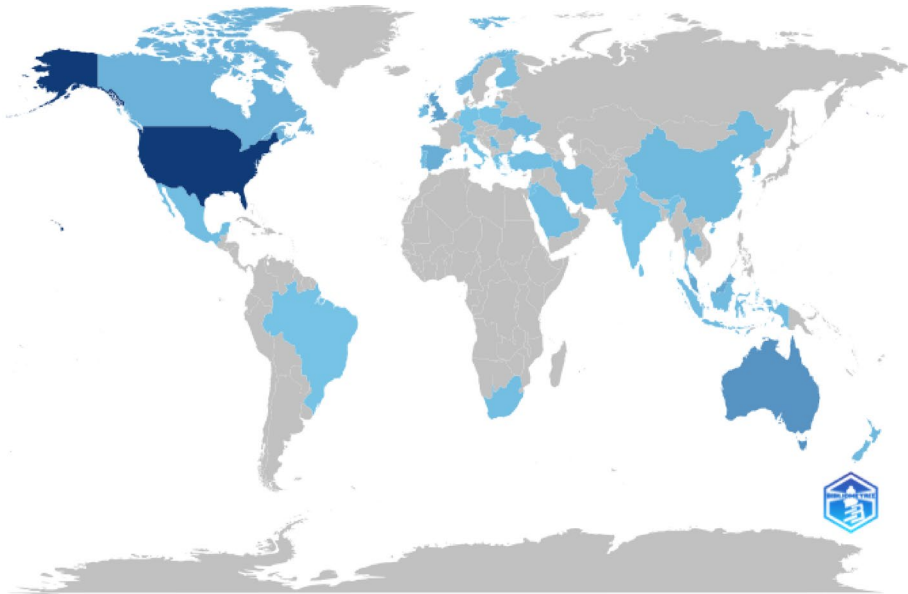


Fig. 3 The world graph of the distribution of the articles by country

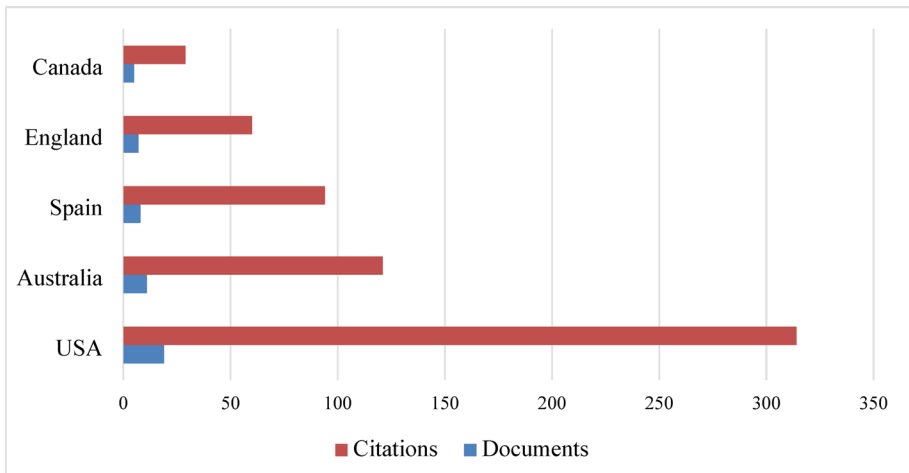


Fig. 4 Most cited countries

Figure 4 displays the total number of documents and citations for authors from the most prominent contributing countries. The United States leads with 19 documents and 314 citations, followed by Australia with 11 documents and 121 citations, and Spain with 8 documents and 94 citations. These results indicate that both publication volume and citation impact are concentrated in these countries.

Figure 5 visualizes the co-authorship network in MC research, where circle size reflects NCs and line thickness indicates collaboration intensity. Colors represent clusters, suggest-

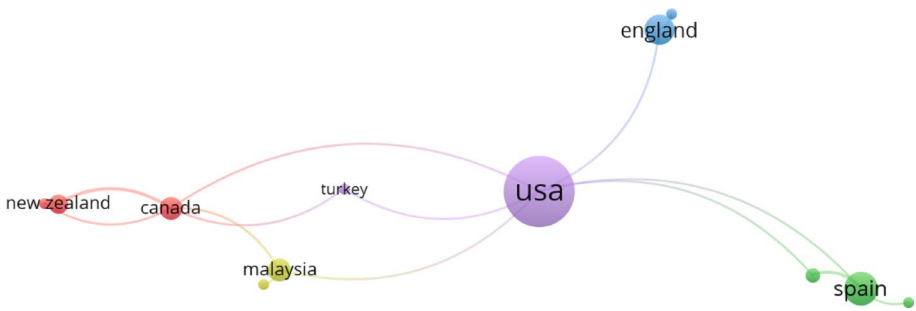


Fig. 5 Co-authorship network of the countries

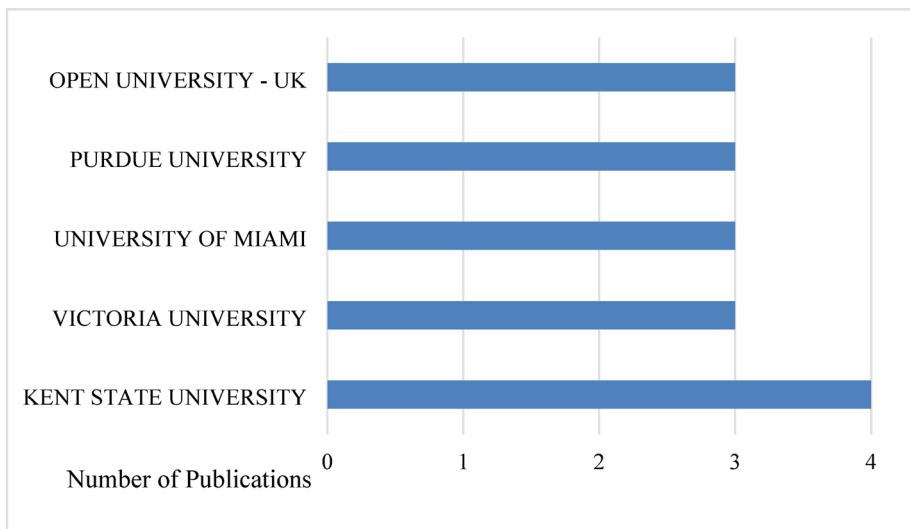


Fig. 6 Number of MC publications of top 5 institutions

ing thematic similarities. The analysis includes 37 countries with at least one publication and 10 citations (van Eck & Waltman, 2018).

The analysis shows that the USA occupies a central position in international co-authorship networks, maintaining strong collaborative links with Spain, England, Türkiye, Canada, Malaysia, and New Zealand. These connections highlight the USA’s role as a hub in global MC research collaboration, with particularly notable ties to both European and non-European partners.

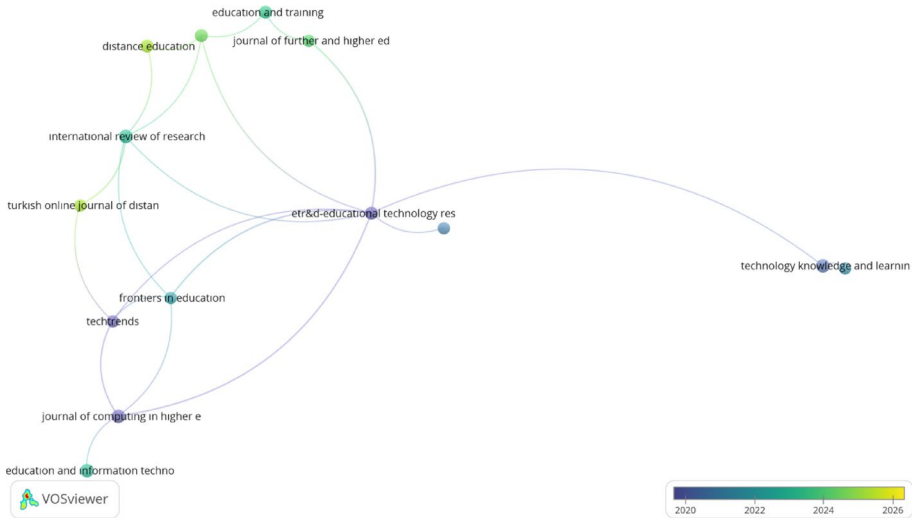
Figure 6 highlights key institutions in MC research, based on author affiliations in the reviewed publications, offering insights into prominent academic and research organizations in the field.

According to Fig. 6, several institutions have contributed three publications each; however, among the most prominent ones, three are based in the United States, with others located in the United Kingdom and Australia—highlighting that leading institutional contributions in this field largely come from English-speaking countries.

Table 2 The 5 most-cited journals regarding MC research between 2015 and 2023

Journals	NPs	TCs
Education and information technologies (EIT)	5	75
International review of research in open and distributed learning (IRRODL)	5	23
Journal of computing in higher education (JCHE)	4	55
Technology knowledge and learning (TKL)	4	93
Educational technology research and development (ETRD)	3	96

NPs, Number of publications;
NCs, Number of citations

**Fig. 7** Citation network map of leading journals

4.1.3 Leading Journals and Authors

The 82 articles are spread across 50 journals. Table 2 ranks the top 5 journals by publication frequency within the reviewed corpus.

Table 2 shows that Educational Technology Research and Development (ETRD) is the most cited journal with 96 citations across 3 articles, followed by Technology, Knowledge and Learning (93 citations, 4 articles) and Education and Information Technologies (EIT) (75 citations, 5 articles). Journal of Computing in Higher Education (JCHE) and International Review of Research in Open and Distributed Learning (IRRODL) also contributed notably, with 55 and 21 citations respectively.

Figure 7 presents a citation network map of journals with at least one article and 10 citations, showcasing their impact on MC research. Connections highlight the influence and significance of these journals in shaping the field.

Figure 7, created with VOSviewer, reveals multiple clusters among leading journals, with citation linkages connecting a subset of them. Metrics such as number of documents, citations, and total link strength indicate a concentrated scholarly network in MC research. Journals like Technology, Knowledge and Learning, Education and Training, and Distance Education stand out for their strong citation connections, highlighting their central role in

disseminating and shaping MC research. The overlay visualization shows that while some journals have been influential for a longer period, others—such as *Technology, Knowledge and Learning*—have gained prominence more recently, reflecting evolving trends in the field.

Figure 8 depicts a network of 29 authors grouped into 11 clusters. The largest node, Sprattle, Michael, signifies high collaboration within its cluster. Prominent partnerships include West–Cheng–Newby, Dudek–Bailie, and Green–Tereseviciene, indicating shared research agendas. Bilateral collaborations, such as Devedžić–Law and Carey–Kumar, reflect more focused research ties, while several smaller clusters highlight niche contributions in specific areas of MC research.

The analysis shifts to co-citation patterns, exploring how authors are interconnected through shared references and identifying influential works shaping academic discourse. Figure 8 visually represents these co-citation patterns within the scholarly network.

Figure 8 presents three color-coded clusters of frequently co-cited authors. The largest cluster, centered around the European Commission and several policy-focused authors, dominates the network, while another cluster features influential figures such as Brown and Abrandt Dahlgren. The third cluster connects authors like Oliver, who link across thematic areas. Dense interconnections within and between clusters indicate strong thematic overlap, with the European Commission emerging as a pivotal citation source in shaping the micro-credential research landscape. Authors such as Abramovic, Gibson, and Gamrat, with the highest TLS values, demonstrate significant cross-disciplinary influence, while thicker lines on the map represent stronger co-citation links, reflecting the extent of shared citations and their contribution to TLS scores.

4.1.4 Analysis of Keywords

Co-occurrence analysis maps the intellectual structure and thematic interrelations in MC research. Figure 9 visualizes keywords from the WoS database, focusing on those appearing at least twice. Circle size reflects keyword frequency, with yellow circles marking the most popular themes.

Figure 9 illustrates the keyword co-occurrence network for MC research between 2015 and 2025. The term “micro-credentials” occupies the most central and prominent posi-

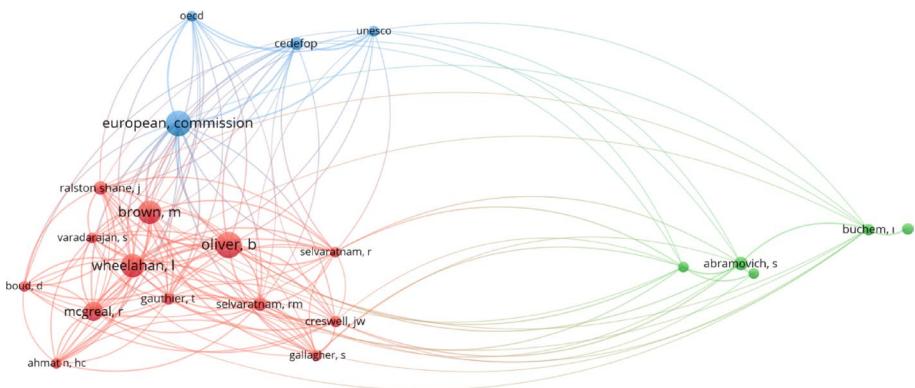


Fig. 8 The most cited authors (co-citation analysis)

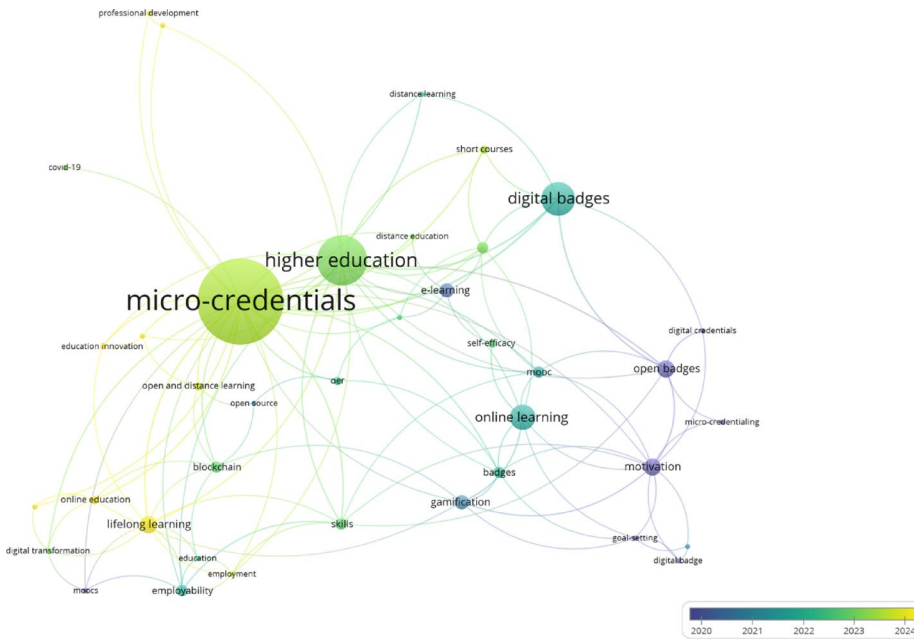


Fig. 9 Analysis of keyword co-occurrence between 2015 and 2025

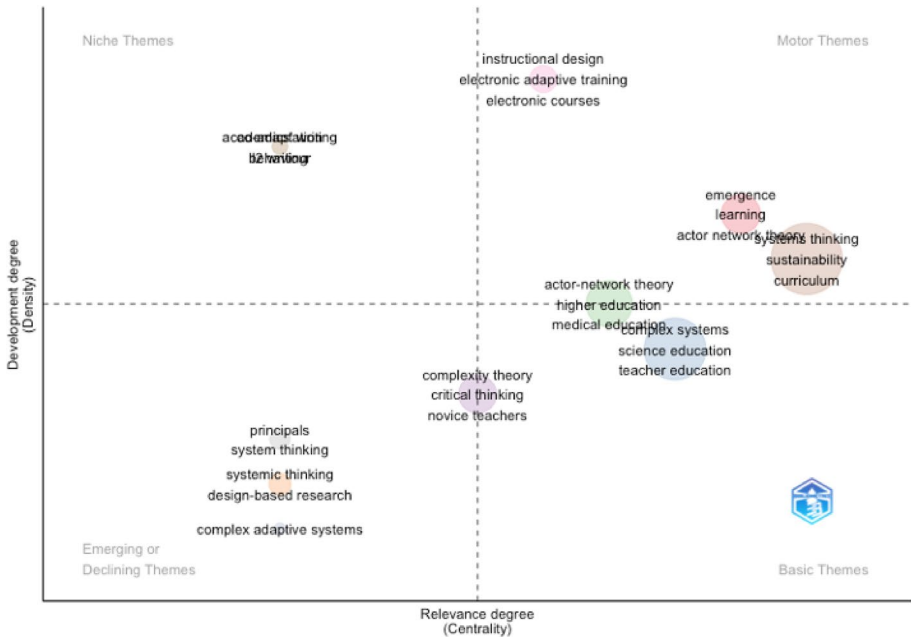


Fig. 10 Thematic mapping of MC research between 2015 and 2025

tion, strongly linked with frequently used keywords such as “higher education,” “digital badges,” “online learning,” and “lifelong learning.” Emerging and recent themes, shown in yellow, include “professional development,” “adult learning,” and “COVID-19,” indicating a shift in research focus toward contemporary educational needs and challenges. The network reveals interconnected thematic areas, highlighting the multidimensional nature of MC-related scholarship.

4.1.5 Thematic Mapping

Figure 10 presents a thematic map of the literature on MC research, identifying clusters of research themes according to their centrality and development level.

Figure 10 presents a thematic map of MC-related literature, categorizing research themes by their degree of development (density) and relevance (centrality).

In the upper right quadrant (Q1 – Motor Themes), topics such as lifelong learning, block-chain, and employability are both central and well-developed, indicating that they drive research in the field and have strong conceptual and practical significance. Closely related motor themes also include online learning, gamification, and microlearning, which represent active and influential areas shaping MC discourse. The lower right quadrant (Q4 – Basic Themes) contains foundational topics like micro-credentials, higher education, digital badges, and e-learning. These themes form the structural core of MC research and are consistently addressed across studies. In the upper left quadrant (Q2 – Niche Themes), areas such as professional development, teacher education, open and distance learning, and open source show high specialization but lower connectivity with the broader thematic network, indicating focused yet less widely integrated research. Finally, the lower left quadrant (Q3 – Emerging or Declining Themes) includes learning analytics, micro-credentialing, and COVID-19. These may represent either early-stage developments with growth potential or topics experiencing a decline in research attention.

This thematic mapping illustrates the dynamic balance between established foundational areas and more specialized or emerging topics, highlighting opportunities to bridge niche and developing themes with the central core of MC research.

4.2 Content Analysis

Content analysis involved the review of 19 academic articles on MCs, selected from journals indexed in the WoS between 2015 and 2025. The selection criteria aimed at capturing the most impactful works in the field by including the two most cited articles from each year. The only exceptions were 2016, when no articles were published, and 2017, when only one article was published. This methodical approach ensured a robust cross-section of scholarly dialogue, providing a comprehensive overview of the evolving discourse on MCs within educational research over the past decade.

4.2.1 Thematic Analysis of the Articles about MCs

This thematic analysis delves into the pivotal themes that surfaced within articles included in this content analysis. Four themes, each encapsulating a critical aspect of how MCs are reshaping educational paradigms have emerged:

The first theme, *Conceptual Foundations and Ecosystem Perspectives*, covers studies defining MCs and exploring their roles within educational systems. Devedžić and Jovanović (2015) and Jovanovic and Devedzic (2015) focus on open badges—viewed here as an early and closely related form of MC—highlighting their potential for recognizing diverse skills, supporting participatory learning, and fostering openness. Carey and Stefaniak (2018) analyze strategic factors for MC/DB implementation, stressing the importance of evidence-based validation and transferability. Systematic reviews by Ha et al. (2023) and Tamoliune et al. (2023) position MCs as tools for lifelong learning, post-pandemic recovery, and institutional innovation, while noting early-stage adoption challenges.

The second theme, *Design Principles and Technological Integration*, addresses how MCs are structured and supported through digital environments. Jahnke et al. (2020) identify 15 design principles for mobile micro-learning systems that can underpin MC delivery. Gerbaudo et al. (2021) introduce a multimedia micro-content model for continuing professional education, and Leach and Hadi (2017) show how modular MOOCs can integrate MC-style recognition—sometimes via digital badges—to acknowledge partial achievement. Shamir-Inbal and Blau (2022) emphasize the role of self-regulation in micro-learning-based MC programs, while Carter and Youssef-Morgan (2022) compare delivery modes, finding online and micro-learning effective for skill development.

The third theme, *Applications in Education and Workforce Development*, captures sector-specific uses of MCs for upskilling, reskilling, and professional growth. Martín-Monje et al. (2018) recommend integrating micro-credentialing into MOOCs to recognize partial engagement and performance. Panwale and Vijayakumar (2025) investigate AI-personalized learning in MBA programs, aligning adaptive content with MC principles. Datta et al. (2025) evaluate MC programs for the energy sector, finding strong outcomes in workforce transition. Scott et al. (2024) report that literacy-focused MCs improved teacher practice and student literacy skills, while Vordenberg et al. (2024) explore MC adoption in pharmacy education, identifying benefits and barriers.

The fourth theme, *Effectiveness, Challenges, and Future Directions*, examines how MCs impact learning outcomes and the factors influencing sustainable adoption. Morris et al. (2019) provide insight into recognition mechanisms—both MCs and related DBs—and their influence on motivation and performance, noting that implementation context matters greatly. Qian et al. (2022) show that micro-learning-based MC models, when combined with active pedagogies, can improve retention and professional attitudes in medical education. Sectoral and integrative reviews emphasize the need for clear alignment with learning outcomes, quality assurance, and employer recognition to ensure MC credibility and long-term viability.

Overall, the literature presents MCs as adaptable, technology-enabled credentials capable of bridging formal, informal, and workplace learning. When DBs are used as part of the MC ecosystem, they function as a visible and verifiable mechanism for recognizing achievement. Across contexts, successful MC implementation depends on robust ecosystem design, effective integration with learning technologies, alignment with learner and labor market needs, and systematic evaluation of impact.

Table 4 Distribution of MCs Publications by Research Method and Model/Design

Method	f	%	Model/design	f
Quantitative	7	37	Survey	2
			Experimental	5
Qualitative	3	16	Case study	2
			Phenomenology	1
Mixed	2	10	Explanatory sequential	1
			Convergent parallel	1
Network analytics	1	5	Learning analytics	1
Theoretical / descriptive	8	42	Literature review	2
			Report	2
			Technical papers	1
			Position paper	1
			Systematic review	2

f, frequency

4.2.2 Theoretical/Conceptual Framework

Of the analyzed articles, only seven are grounded in theoretical foundations, drawing on a diverse range of concepts such as self-regulated learning theory, achievement goal theory, self-efficacy theory, skill acquisition theory, multiple intelligences theory, goal-setting theory, multimedia learning theory, cognitive load theory, human capital theory, principles of individualized learning, and adaptive education. This variety reflects a multifaceted approach to exploring micro-credentials through cognitive, motivational, and skill development perspectives.. In contrast, 12 articles lack specific theoretical frameworks, suggesting a greater emphasis on practical applications or empirical observations.

4.2.3 Research Design

The research designs utilized in the articles have been categorized into five groups: quantitative, qualitative, mixed methods, network analytics, and theoretical/descriptive. Detailed information on all the research designs and models used in the articles is available in Table 4. It should be noted that a single study may employ multiple methods, models, or designs.

Among the selected articles, 37% employed quantitative methods, 16% qualitative methods, 10% used mixed methods, 5% applied network analytics, and 42% were theoretical or descriptive in nature. Quantitative studies included survey and experimental designs, while qualitative research primarily involved case studies and phenomenology. Mixed methods comprised explanatory sequential and convergent parallel designs, and the single network analytics study utilized learning analytics. Theoretical and descriptive studies encompassed literature reviews, reports, technical papers, position papers, and systematic reviews, reflecting a broad and varied approach to examining MC in the field.

4.2.4 Data Collection Tools

The most frequently used data collection tools, in order of prevalence, are questionnaires (31.6%), interviews (21.1%), pre- and post-tests (15.8%), and scales (10.5%). Other tools include database searches (10.5%), learning analytics (10.5%), MOOC platform logs (5.3%), panel discussions (5.3%), and standardized rubrics (5.3%). This distribution reflects a strong

reliance on structured instruments and direct participant engagement, with notable use of standardized assessments and secondary data searches. The integration of digital trace data, such as platform logs and learning analytics, further indicates an increasing emphasis on data triangulation and technology-driven evidence in micro-credentials research.

4.2.5 Participants

Employees and professionals (26.7%), undergraduate students (20%), graduate students (20%), and instructors or academic staff (20%) constitute the majority of participants in the reviewed studies, with the remaining 13.3% classified as other kind of learners, such as MOOC participants or university graduates. This distribution shows that MC research engages a broad spectrum of stakeholders, from current students to industry professionals and academic staff. While the balanced representation suggests diverse perspectives, the relatively high proportion of participants from higher education contexts highlights a continued emphasis on MCs' role in formal learning environments.

4.2.6 Variables/Research Interests

“Academic Success” and “Engagement/Achievement” have been the most frequently used dependent variables, each appearing in 26.3% of the studies ($n=5$). These are followed by workplace application and career-related outcomes (15.8%), performance or skill-based outcomes such as fluency and accuracy (15.8%), and satisfaction or perception measures (10.5%). Goal achievement appears in one study (5.3%). This distribution indicates that while academic performance and learner engagement remain central focal points in MC research, there is a growing interest in exploring broader impacts such as workplace applicability, skill development, and perceived value.

5 Discussion and Conclusion

The bibliometric analysis of MC literature from 2015 to 2025 highlights the field's growth, with studies like Cartis et al. (2023) and Rajabalee et al. (2023) emphasizing its conceptual development in ODL. A significant increase in publications, especially after 2017, noted by Varadarajan et al. (2023) and Ahsan et al. (2023), reflects the rising demand for lifelong learning in a dynamic job market. This trend is likely driven by the rapid digitalization of industries and the increasing recognition of the need for continuous skills upgrading. MCs address this demand by offering targeted and flexible opportunities for learners to align education with specific workforce needs. Msweli et al. (2022) further links this trend to professional development in ODL contexts. Advancements in digital technologies, enabling accessible and skill-specific credentials, are crucial drivers of this shift, as noted by Wolz et al. (2021) and Alsobhi et al. (2023), underscoring MCs' alignment with flexible and cost-effective ODL solutions.

The analysis reveals that the USA, Australia, Germany, and England lead MC research, particularly in ODL systems, as supported by Rajabalee et al. (2023) and Tamoliune et al. (2023). Identifying key countries and institutions highlights global research dynamics and informs targeted research agendas. Their approaches set examples that other regions can

adapt to expand MC adoption globally. International collaboration is significant, with notable bibliometric coupling and co-authorship networks, such as the USA's strong partnerships with Türkiye (Ahsan et al., 2023; Wolz et al., 2021) and collaborations by Australia, China, and Germany (Msweli et al., 2022). This emphasizes the importance of cross-border collaborations and leveraging shared expertise to advance the field further. The USA's dominance stems from its robust R&D budget, prestigious universities, and an innovation-driven academic culture (Cartis et al., 2023; Alsobhi et al., 2023; Hebebcı, 2021; Talan, 2021), underscoring its leadership in ODL-focused MC research.

This leadership may be institutionally reinforced by the consistent contributions of US-based universities such as Kent State, Purdue, and Miami University. Their visibility in the literature suggests that these institutions may have adopted strategic approaches aligned with the development of micro-credential research within ODL systems. In addition, the prominence of international institutions such as The Open University (UK) and Victoria University (Australia) points to the global diffusion of micro-credentials and implies that ODL-focused universities are becoming key actors in this expanding domain. The strong representation of American institutions reflects the country's central role in driving both research productivity and the strategic direction of institutional engagement in the field of micro-credentials.

Among the most influential journals in the field, ETRD stands out with 96 citations across three articles, followed closely by TKL (93 citations) and EIT (75 citations). These journals serve as critical outlets for micro-credential research, particularly in ODL contexts, reflecting a strong focus on technology-enhanced learning. Journals such as JCHE and IRRODL also play a notable role, consolidating the scholarly network around a few high-impact publication venues. This visibility helps shape academic discourse and guides future submissions toward impactful publication channels (Ahsan et al., 2023; Hebebcı, 2021).

Regarding authorship, the co-authorship network reveals 29 active authors across 11 clusters, suggesting a modest but growing level of collaboration. Scholars like Spratle, Michael appear as central figures within their clusters, while bilateral ties (e.g., Carey–Kumar; Devedžić–Law) suggest more focused research efforts. The relatively limited collaboration landscape still indicates an early-stage research field, where individual or small-team initiatives prevail. Strengthening interdisciplinary cooperation may help address complex challenges and expand the impact of MC research globally (Rajabalee et al., 2023; Alsobhi et al., 2023).

Co-citation analysis highlights the European Commission and policy-oriented authors as central nodes, reflecting the field's strong policy underpinnings. The European Commission's centrality in the co-citation network may suggest its ongoing role in shaping policy frameworks and funding strategies aligned with micro-credentialing efforts in higher education. Influential contributors such as Brown, Abrandt Dahlgren, and Oliver appear to bridge conceptual frameworks and thematic domains, while scholars like Abramovic, Gibson, and Gamrat—identified with high Total Link Strength—demonstrate notable cross-disciplinary relevance. These patterns point to an evolving ecosystem where policy, pedagogy, and practice are increasingly interconnected.

Keyword co-occurrence analysis reveals that the term “micro-credentials” holds a central position within the knowledge structure of the field, strongly associated with keywords such as “higher education,” “digital badges,” “online learning,” and “lifelong learning” (Ahsan et al., 2023). The appearance of newer themes like “professional development,” “adult learn-

ing,” and “COVID-19” suggests a gradual shift in scholarly attention towards emerging societal and educational demands. This evolution may reflect how MCs are increasingly positioned as agile instruments to address upskilling needs during global disruptions and in response to labor market transitions. Thematically, the field demonstrates both continuity in foundational concepts and diversification into newer directions, offering fertile ground for future research.

Building upon the keyword co-occurrence analysis, which highlighted the central role of terms like “micro-credentials,” “higher education,” “digital badges,” and “online learning,” the thematic mapping further elucidates how these foundational concepts shape the field’s intellectual structure. These keywords not only dominate the co-occurrence network but also appear as central nodes in the Basic Themes quadrant of the thematic map, reinforcing their status as conceptual anchors in MC research.

Motor themes such as lifelong learning, blockchain, and employability emerge as well-developed and highly relevant areas, possibly due to their alignment with global workforce transformation agendas and the rising demand for flexible learning pathways. Complementary themes like microlearning, gamification, and online learning suggest a growing pedagogical focus on personalized, modular education—hallmarks of the micro-credentialing movement.

Conversely, niche areas like professional development, teacher education, and open source show high density but lower centrality, indicating specialization without broad thematic integration. Meanwhile, emerging or declining themes such as learning analytics and COVID-19 may reflect either transient surges in research interest or the repositioning of these topics within broader domains like AI in education and digital transformation.

Taken together, the co-occurrence and thematic mapping analyses reveal a dynamic and multilayered landscape in which core themes are well-established, while newer or peripheral topics present opportunities for deeper integration. Future research could benefit from bridging these zones—aligning exploratory themes with dominant constructs—to enhance theoretical cohesion and policy relevance in MC scholarship.

In addition to the keyword-based thematic clusters derived from co-occurrence analysis—which revealed the prominence of concepts like micro-credentials, higher education, digital badges, and online learning—the complementary content-driven thematic analysis presented in this study brings a broader pedagogical perspective. Unlike the bibliometric mapping techniques generated through tools like R-Studio, this second analysis was conducted through qualitative content examination of selected articles.

The findings highlight four major thematic directions: Digital Badges and Motivation (Roy and Clark, 2019), Micro-learning and Educational Technologies (Ahsan et al., 2023), E-learning Environments and Assessment (Hills & Hughes, 2016; Xiong & Suen, 2018), and Teacher Professional Development (Tamoliune et al., 2023). These themes reflect a growing emphasis on flexible, competency-based, and learner-centered approaches. DBs are increasingly used to support motivation and recognition in both formal and informal contexts, particularly in ODL settings like MOOCs (Gamrat et al., 2014; Jobe, 2013). Micro-learning addresses the need for modular, just-in-time education (Jahnke et al., 2020; Olsson et al., 2015), while online assessment practices are evolving to reflect workforce-aligned competencies (Xiong & Suen, 2018).

This content-focused analysis complements the bibliometric results by highlighting not only conceptual patterns but also instructional innovations and policy-driven shifts.

Together, they provide a holistic view of how micro-credentials are being integrated into the broader educational landscape, particularly in open and distance learning contexts (Carter & Youssef-Morgan, 2022; Ward et al., 2023).

The review of the most-cited studies on micro-credentials (MCs) reveals a limited incorporation of well-established theoretical frameworks, exposing a critical gap in the current literature (Ahsan et al., 2023). While theories such as self-regulated learning, cognitive load, and skill acquisition have been utilized sporadically, only a minority of studies embed these systematically. This underlines the need for stronger theoretical grounding to enhance explanatory power and enable cross-study comparisons, particularly as MCs continue to evolve within complex learning ecosystems.

In terms of research design, the field demonstrates a methodological diversity: 37% of the studies employed quantitative designs—mostly experimental—while 16% adopted qualitative approaches, 10% used mixed methods, and 42% were conceptual or descriptive (e.g., technical papers, systematic reviews). This distribution suggests a growing interest in practical exploration alongside theoretical reflection (Tamoliune et al., 2023; Thi Ngoc Ha et al., 2023). The emergence of network analytics and learning analytics in some recent studies also points to an increasing reliance on data-driven approaches, particularly in large-scale open platforms like MOOCs.

With regard to participants, MC studies primarily engage higher education students, academic staff, and professionals, reinforcing the field's relevance to both formal education and lifelong learning. The most frequently studied variables—academic success, engagement, and career-related outcomes—highlight MCs' potential in addressing both institutional goals and individual advancement.

Additionally, data collection strategies indicate a strong preference for structured tools such as questionnaires and standardized assessments, yet there is a visible trend toward triangulation via MOOC logs and platform data. This shift may reflect increasing emphasis on real-world evidence and scalable evaluation strategies in MC deployment.

Overall, the findings suggest that while MC research is gaining conceptual and methodological maturity, it remains an emerging domain in need of more cohesive theoretical scaffolding and rigorous empirical validation. A promising path forward may involve integrating adaptive learning models, learner analytics, and workplace-oriented metrics to better capture the evolving role of MCs in diverse educational and professional contexts.

This study has several limitations, each of which stems from informed methodological choices and practical considerations:

Scope of Analyzed Publications: The content analysis was limited to 19 highly cited publications. This deliberate choice aimed to capture the most influential contributions shaping the field. Moreover, conducting a full thematic analysis on a significantly larger corpus would have required considerable time and labor. Given that this study already incorporates a comprehensive bibliometric analysis, a focused sample was selected to maintain analytical depth while ensuring manageability. However, this may have excluded emerging perspectives or recent works with low citation counts. Future research could extend this scope to include a broader range of publications—including less-cited and newer studies—to capture more diverse insights and evolving trends.

Exclusive Use of WoS Database: This study relied solely on the Web of Science (WoS) database. WoS is widely recognized as one of the most prestigious and influential indexing platforms in academia (Durak et al., 2024). Therefore, it was chosen to ensure data reliability

and methodological consistency. However, limiting the analysis to WoS may have excluded important studies indexed in Scopus, ERIC, Google Scholar, or other domain-specific databases. To address this limitation, future research is encouraged to utilize multiple databases.

Citation-Based Selection Criteria: In content analysis section, the selection of articles was based on publication year, with the two most cited articles from each year being included in the analysis. This approach ensured representation across different time periods and minimized temporal bias. However, a limitation remains in that only the most highly cited articles per year were selected, which may exclude other relevant but less frequently cited contributions.

Beyond methodological considerations, the review also identified several thematic gaps and future research directions regarding the contextual scope, equity dimensions, and long-term impact of micro-credentials. Most of the reviewed studies focused on higher education contexts, reflecting the strong association between MCs and formal learning environments. However, micro-credentials are increasingly relevant in other sectors, including K–12 education, vocational training, and workplace learning. Expanding research across these domains would help reveal sector-specific challenges and opportunities, as well as the broader societal impact of MCs.

Although several studies addressed learner engagement and academic success, there remains a need for more focused investigation into how micro-credentials support equity, inclusion, and accessibility—particularly for underserved communities. Future research could explore these dimensions more directly, especially in relation to global education challenges and digital divides.

The cross-sectional nature of most studies in the current corpus limits our understanding of the sustained effects of micro-credentials. Longitudinal studies would be instrumental in assessing their long-term influence on learners' career advancement, motivation, and life-long learning trajectories.

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