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Research Article

INDUSTRIAL PERSPECTIVE ON MICRO-CREDENTIALS: A COMBINED SYSTEMATIC LITERATURE REVIEW AND BIBLIOMETRIC ANALYSIS

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Abstract
This study aims to explore the development and application of micro-credentials (MCs) as an alternative, competency-based learning model increasingly adopted in higher education and industry. Micro-credentials represent an alternative, competency-based learning model increasingly adopted in higher education and industry. The method used is a combination of a systematic literature review (SLR) and bibliometric analysis, designed to examine research trends, learning models, curriculum structures, and skill areas associated with micro-credentials. Data from 482 documents indexed in Scopus and Web of Science (WoS) from 2008 to 2023 were analyzed. The findings reveal a growing global interest in MCs, particularly in digital, information, and technical skills fields. The bibliometric analysis highlights the United States as the leading country in micro-credentials research, followed by Australia and the United Kingdom. The thematic analysis identifies four primary learning models used in micro-credentials: Project-Based Learning (PBL), Self-Directed Learning, Problem-Based Learning, and Game-Based Learning. Additionally, micro-credentials curriculum structures often adopt modular, blended, and online formats to offer flexible, accessible learning pathways. Industry engagement is critical in MC, ensuring curriculum relevance to workforce needs through collaborations that define skill requirements, offer internships, and co-develop assessments. Micro-credentials evaluation methods focus on competency-based assessments, including portfolios and direct performance evaluations, providing practical evidence of learners' skills and readiness for professional roles. The implication of this study is to provide a structured foundation for institutions and policymakers to design more effective, standardized, and industry-aligned micro-credential programs, while encouraging further research on long-term outcomes, transferability, and recognition across education and labor systems.

Keywords: Bibliometric, Industry, Learning Model, Micro-Credential, Systematic Literature Review

INTRODUCTION

In the current era of scientific and technological advancement, diverse skills and knowledge have become essential for individuals to compete globally. From industry to higher education, every sector demands that individuals possess a broader range of competencies, extending beyond a single field or discipline. Therefore, individuals are expected to be more adaptable in training and developing 21st-century skills. The high cost and lengthy time required to pursue higher education often present barriers to acquiring knowledge and skills in a single discipline (Kebritchi et al., 2017; Okolie et al., 2020). For instance, while the industry and higher education sectors require technological proficiency, not all programs offer technology-related courses. This situation makes it challenging for individuals to acquire the diverse skills necessary to compete in a globalized world, especially when higher education has yet to become sufficiently flexible. On the other hand, some educational institutions have started offering more flexible, short-term courses or training that focus on job-related skills (Ralston, 2021; Olcott, 2022).

Short-term courses or training programs have emerged as solutions offered by educational and certification institutions to support skills development. One popular concept is micro-credentialing, which gives learners greater flexibility to acquire skills and knowledge according to speed, location, and learning time (Olcott, 2022; Alangari, 2024; R. C. Johan et al., 2025). Initially, Massive Open Online Courses (MOOCs) were developed to accommodate formal learning that requires high costs. MOOCs and micro-credentials have become alternative bridges for lifelong learning (Johan, 2016; Lee & Tan, 2023). Micro-credentials operate at the intersection of academia and industry, serving as a "bridge" for learners to acquire learning integrated with the world of work (Ponte & Saray, 2019). Thus, micro-credential-based learning has become increasingly popular, attracting certification bodies, industries, educational institutions, and individuals. Micro-credentials also offer a variety of skills and knowledge, such as IT and computer science from The Open University, English language skills offered by Indonesia's Ministry of Education in collaboration with Ohio State University, data analysis from Google, and "Patient Journey and System Design" from Deakin University. These skills emphasize practical, multidisciplinary competencies not limited to a single field.

The growing interest and development in micro-credentials have driven numerous studies focusing on this topic, from development to evaluation of micro-credential-based learning systems. For instance, Peisachovich (2021) developed simulation-based micro-credentials for healthcare professionals, especially nurses, to enhance communication and leadership skills. This study found that combining micro-credentials with simulation-based education offers benefits for learners, such as more innovative learning and more structured assessment of learning outcomes. Another study by Howard & Babb (2022) developed an online certification program, The Facilitating Learning Online Certification (FLOC), which integrates micro-credentials. FLOC combines various additional courses that faculty members can choose to meet the micro-credential requirements for certification. Based on the results of these studies, micro-credentials now serve not only as a means to "gain knowledge" but also to offer skill certifications and digital badges (Fischer & Stabauer, 2022).

Furthermore, research by Zou et al., (2024) indicates an improvement in students' job performance following implementing micro-credentials, highlighting micro-credentials as an effective strategy to enhance students' learning quality. These studies underscore the growing research on micro-credentials within industry and higher education sectors. Micro-credentials are designed to enhance skills required in today's job market, with diverse topics and learning models (Shanahan & Organ, 2022). However, questions arise regarding the most necessary skills in the industry and higher education sectors, which often become the focus of micro-credential-based learning. In addition, there is a lack of synthesis regarding how micro-credentials are conceptually positioned across disciplines, and how their learning models align with workforce demands. This fragmentation hinders the field's ability to build cumulative, theory-informed knowledge.

Despite its growing popularity, current research on micro-credentials tends to insufficiently address structural and systemic challenges. Issues such as standardization of learning outcomes, the absence of robust quality assurance mechanisms, and the unclear articulation of micro-credentials within formal qualification systems remain underexplored. These limitations have the potential to create confusion among learners, institutions, and employers regarding the recognition and portability of micro-credentials. In addition, the conceptual framing of micro-credentials remains fragmented. Few studies have systematically examined their academic positioning, how their curricular models are designed in alignment with industry needs, or what skill domains are consistently emphasized across sectors. Without

a cohesive analytical framework, existing literature struggles to capture the full complexity and practical utility of micro-credentials. To frame the inquiry, this study adopts a competency-based education (CBE) perspective, which emphasizes demonstrated proficiency and job-relevant performance over the accumulation of academic credit. This framework is especially relevant to micro-credentials as it supports the shift from traditional education models toward applied, outcomes-based learning pathways (Ahsan et al., 2023).

MC refers to a specialized form of learning focused on mastering job competencies without emphasizing formal academic degrees. The core concept of micro-credentials is to obtain a certificate or non-degree competency in a specific skill area through a relatively short training period, in contrast to typical university degree programs (Maxwell & Gallagher, 2020; Pelletier et al., 2022). This certification programs generally concentrate on skills highly demanded in the job market. Therefore, micro-credentials are based on the notion that if the acquired competencies are market-accepted, individuals can pursue a partial undergraduate degree to achieve specific competencies. Thus, micro-credentials represent a form of formal, competency-based learning designed to be completed in a shorter timeframe than traditional academic degrees.

One of the main advantages of micro-credentials (MC) is the flexibility of learning, which contrasts with the lengthy time commitment required for a bachelor's degree program. Additionally, MC enables participants to develop practical skills that are relevant and in demand in the job or industry sector, creating individuals who are ready to enter their chosen fields (Brown & Nic-Giolla-Mhichil). There are at least four primary benefits of MC implementation: (1) personalization, where MC offers learning that can be tailored to individual needs and goals, both for educators and learners; (2) competence, as MC focuses on developing specific skills or competencies; (3) flexibility and cost-efficiency, with MC often delivered online, allowing learners to access education anytime and anywhere, thereby reducing classroom costs and geographic barriers; and (4) collaboration, where MC provides a shared platform for educators and learners to discuss, practice, and share knowledge more effectively (Hunt et al., 2020).

MC has become a promising strategy for various individuals and industry sectors. This aligns with the view that MC can (1) enhance career learning and learning outcomes; (2) enable the delivery of education closely aligned with the needs of industry and higher education; (3) be low-cost; (4) include digital badges to support educational development; and (5) use digital badges as evidence of skill mastery, contributing to career advancement or further education (Gauthier, 2020). The description of MC benefits (Hunt et al., 2020), highlights two main aspects: (1) a focus on career skills to support competitiveness in the industry and (2) flexibility and cost-efficiency, where MC helps address financial and geographic constraints in pursuing formal education. These two aspects are the key factors driving the popularity of MC as an alternative skill-learning and development strategy.

This study aims to systematically review the literature (Systematic Literature Review or SLR) and explore research that considers micro-credentials as a primary topic. Thus, the objectives of this study are to (1) identify the forms, models, and curricula developed by industry and frequently discussed in micro-credential-related research and (2) identify the skills or fields of knowledge that are often the focus of micro-credentials in the industry and higher education sectors. Through the SLR approach, this study hopes to uncover connections, conclusions, and syntheses from publications relevant to this research topic (Lame, 2019).

RESEARCH METHOD

This study integrates a Systematic Literature Review (SLR) with a bibliometric analysis to comprehensively examine scholarly research on micro-credentials (MC). The bibliometric component is structured around two main objectives, namely performance analysis and science mapping (Donthu et al., 2021). First, the performance analysis aims to evaluate publication trends, identify the most prolific countries, authors, and sources, and assess citation impact to reveal the overall productivity and influence within the MC research landscape. Second, science mapping is employed to explore the conceptual structure of the field by identifying major research themes, core topics, and evolving key concepts. This includes the visualization of intellectual patterns and thematic clusters that shape the development of micro-credential scholarship. This study adheres to rigorous methodological standards for systematic reviews, following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2016) to ensure transparency, replicability, and comprehensiveness in both the review and bibliometric procedures.

This structured literature analysis process consists of three main stages. The first stage, planning a reproducible review methodology, includes designing the review methodology, developing inclusion and exclusion criteria, and constructing a literature search approach to ensure the accuracy and repeatability of the review process. The second stage is data screening, synthesis, and analysis, where data is rigorously filtered, information is synthesized, and an in-depth analysis is conducted on relevant literature. The final stage is dissemination of results, involving comprehensive reporting of findings, including the preparation of a detailed report and publication of this study's results.

In this study, we utilized two databases to identify relevant literature. These two databases were chosen because they cover high-quality journals and conference proceedings that are widely indexed, making them comprehensive and reliable resources for scientific literature searches (Pranckutė, 2021). The search strategy began by entering relevant keywords into Scopus and WoS search interfaces. The keywords were designed to capture various aspects of micro-credentials in the industry context, including terms such as "microcredentials", OR "microcredential" OR "micro-credentials", OR "micro-credential", OR "digital badges", OR "digital badge", OR "open badges" OR "open badge" OR "nano-credentials" OR "nano-credential" OR "micro-qualifications" OR "MicroMasters" OR "nano-degrees" OR "online short courses" AND "curriculum" OR "curricula" OR "learning design" OR "design instructional" OR "learning strategy" OR "learning method" OR "learning models" OR "lesson plan" OR "syllabus" OR "course."

After entering the keywords, we applied filters to limit the results to English-language and finalized articles. Additionally, we ensured that the selected articles originated from relevant journals and conference proceedings, covering publications from 2008 to 2023. A bibliographic export was conducted in RIS format and processed through Biblioshiny (RStudio) and VOSviewer for further mapping of bibliometric indicators.With this comprehensive search strategy, the study aims to provide an in-depth overview of the types or models of curricula applied in micro-credentials and the dominant topics or occupational fields available within micro-credentials from an industry perspective.

We defined specific selection criteria to select studies related to the industry perspective on micro-credentials before applying the systematic search protocol. These criteria include: (1) The articles included in the study must originate from relevant journals and conference proceedings. (2) Articles must be in English to ensure consistent understanding. (3) Articles must be in their final status, not in press or under revision. (4) Articles published between 2008 and 2023. (5) Relevant articles should discuss the types or models of curricula applied in micro-credentials and the most dominant topics or occupational fields available in micro-credentials from an industry perspective. (6) Articles must be primary or empirical research. Systematic reviews, bibliometric analyses, and meta-analyses were excluded to ensure analytical originality. This systematic approach ensures that the selected studies provide a comprehensive and reliable view of how micro-credentials are implemented and utilized in industry-focused settings.

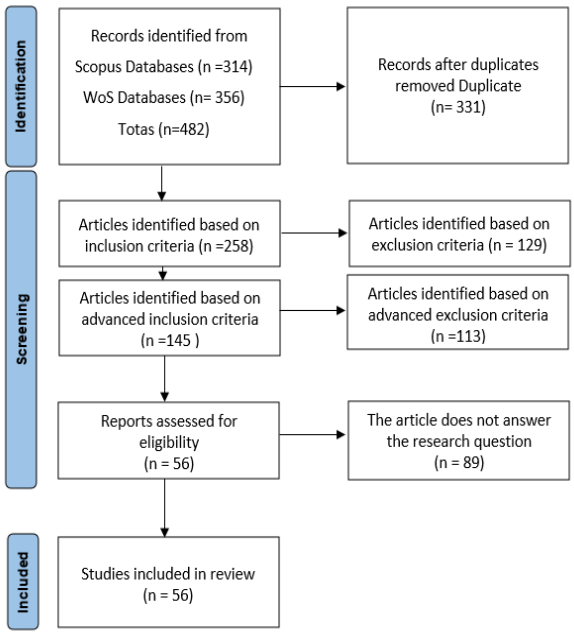

Figure 1. A Flow Diagram of PRISMA (Page et al., 2021)

Data extraction in this study involved systematically analyzing each article based on key bibliographic and analytical categories, including author, title, journal name, year of publication, research methodology, forms and models of micro-credentials, and the skills or disciplinary fields emphasized in industry and higher education contexts. To ensure methodological rigor and relevance, the selected articles were subjected to a quality appraisal using a set of predefined criteria adapted from established methodological guidelines. These criteria are summarized in Table 1, serving as a structured framework for evaluating the empirical and conceptual robustness of each study.

Table 1. Article assessment criteria

No.	Criteria	Description	Score (Yes = 1 / No = 0)
1	Clarity of research question and study objectives	The article explicitly states its research purpose or central focus.	Yes / No
2	Appropriateness of research design	The research design is suitable for the study's aim (e.g., empirical, exploratory, descriptive).	Yes / No
3	Explanation of inclusion and exclusion criteria	The article clearly outlines how data or articles were selected and excluded.	Yes / No
4	Primary empirical study, not a systematic review or bibliometric paper	The article is based on original or primary data, not a secondary review, meta-analysis, or bibliometric study.	Yes / No
5	Description of data collection methods	The article describes how data were collected (e.g., surveys, interviews, document analysis, observation).	Yes / No
6	Explanation of data analysis methods	The analytical techniques are clearly and logically explained (e.g., statistics, thematic analysis, coding).	Yes / No
7	Findings supported by sufficient evidence	Results are presented with adequate empirical support (e.g., quotes, tables, figures, matrices).	Yes / No

As presented in Table 1, each study was evaluated across seven quality dimensions using a binary scoring system (Yes = 1; No = 0). This scoring method ensured a transparent and consistent process for assessing the methodological rigor of the included studies. Through this appraisal, studies meeting the minimum threshold for empirical credibility and analytical coherence were systematically identified.

To strengthen the reliability of this process, the evaluation framework was adapted from the Joanna Briggs Institute (JBI) Critical Appraisal Checklist, which is widely used for assessing the quality of qualitative, mixed-method, and systematic review studies (Peters et al., 2020). Furthermore, studies scoring at least 4 out of 7 points were prioritized for in-depth thematic synthesis, ensuring that only studies with high empirical credibility, conceptual clarity, and analytical robustness were included in the interpretive phase of the review. This quality assessment criterion was designed to assist researchers in evaluating the relevance of articles to the research objectives, specifically to answer the following Research Questions (RQs):

RQ1: What is the academic performance and conceptual structure related to Micro-Credentials?

RQ2: What are the forms, models, and curricula of Micro-Credentials developed in related to Micro-Credentials?

RQ3: Which skills or fields of study are commonly featured as topics in Micro-Credentials within the industry sectors?

We adopted a two-stage reporting approach that integrates bibliometric performance analysis and qualitative thematic analysis to comprehensively capture developments in micro-credential research. The performance analysis focused on three primary dimensions: (1) the longitudinal growth of publications on micro-credentials between 2008 and 2023, (2) identification of the most productive publication sources, including journals and conference proceedings, and (3) mapping of countries contributing most actively to micro-credential research. These insights were generated using Biblioshiny in RStudio, providing descriptive statistics and visual outputs such as bar charts and trend lines to highlight global research productivity.

In the second stage, thematic analysis was conducted on a subset of 56 articles that met the inclusion criteria. Through manual coding aligned with the study's objectives, the selected literature was analyzed to identify curriculum forms, instructional models, and skill domains frequently emphasized in both industry and higher education contexts. This qualitative synthesis helped uncover conceptual structures, highlight frequently recurring topics, and link curricular strategies with labor market competencies. This two-tiered reporting process allows for a clearer understanding of both the bibliometric landscape and the substantive content of micro-credential literature, offering a foundation for future inquiry and practical application.

RESULTS AND DISCUSSION

Performance Anlysis

Figure 2 displays the growth in the number of articles related to micro-credentials indexed in the Scopus and WoS databases from 2008 to 2023. The development of publications on micro-credentials reveals an increasingly upward trend year by year, based on Scopus and Web of Science (WoS) data. It should be noted that data for the year 2024 is excluded from this analysis, as the year is still ongoing. Publications for the current year have yet to fully accumulate in the databases, making it challenging to capture a complete and accurate reflection of publication numbers and trends. The available data may represent only a fraction of the total publications for 2024, so including it could lead to unrepresentative conclusions.

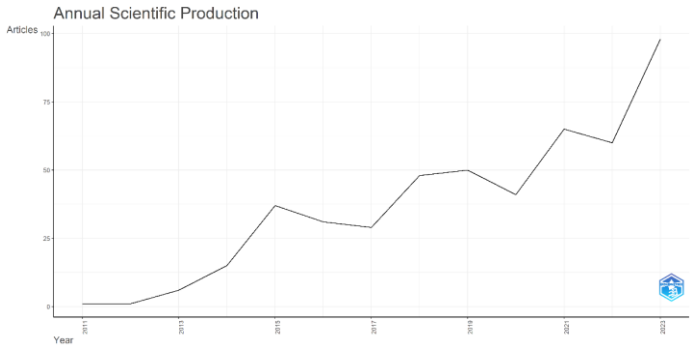

Figure 2. Growth of Micro-credential publications

The trend began with a relatively small number of publications between 2011 and 2015, averaging fewer than 20 articles per year. Notably, from 2008 to 2010, no publications on micro-credentials were recorded. The slow increase in publications during this early phase reflects the initial introduction of the micro-credential concept within academic and industry circles. However, from 2016 onwards, a more significant rise is evident, with publications reaching 37 articles in 2016, increasing to 48 in 2018, and further to 50 in 2019. This surge underscores the growing interest in micro-credentials as an educational approach that aligns well with labour market demands. Industries and academic institutions began recognizing micro-credentials as a viable means of certifying specific, in-demand skills suited to the digital era's needs and a globalized economy.

Following 2020, the rise in publication numbers became even more pronounced. 2020, there were 41 publications, and this figure nearly doubled to 98 articles by 2023. This substantial increase can be attributed to the broader adoption of educational technology, driven by the demand for flexible online learning and skill development during the COVID-19 pandemic. This situation spurred educational and training institutions to embrace micro-credentials as a flexible approach to delivering relevant workplace skills. Data from 2023 reflect that micro-credentials have emerged as a highly popular research topic, with nearly 100 publications underscoring the importance of this approach in addressing the needs of both industry and higher education. The rapid growth of publications post-2020 highlights a paradigm shift toward flexible, competency-based education. It confirms the relevance of micro-credentials in addressing global upskilling and workforce alignment challenges.

Based on Figure 3, the most productive sources in publishing micro-credential research include the ASEE Annual Conference and Exposition and CEUR Workshop Proceedings, each contributing 15 publications, representing approximately 3.11% of the total 482 publications. TechTrends follows with 13 publications, accounting for about 2.70% of the total research output. Other significant sources include the ACM International Conference Proceeding Series with 11 publications (2.28%) and the Proceedings of the Frontiers in Education Conference with ten publications (2.07%). These sources illustrate the range

of academic venues where micro-credential research is disseminated, highlighting the importance of conferences and journals focused on educational technology and innovation. The dominance of conference proceedings implies that the field is still emerging, with scholars actively presenting preliminary findings and novel frameworks. However, stable growth in journals such as TechTrends and Computers & Education suggests a gradual maturation of research quality and scholarly depth.

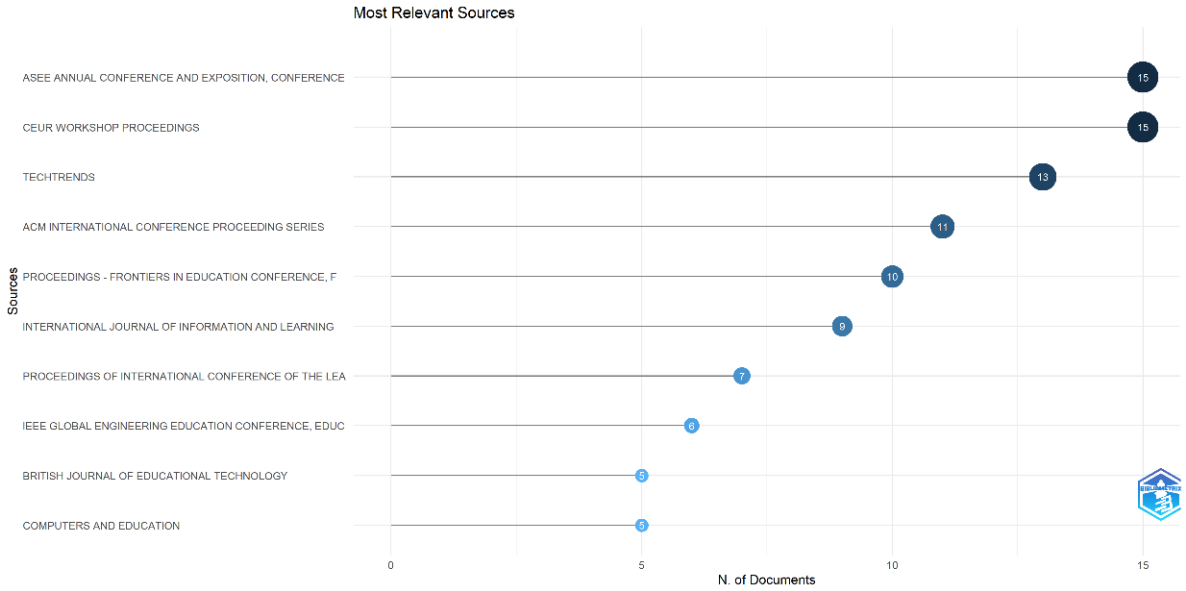

Figure 3. The most productive source publishing Micro-Credentials research

The International Journal of Information and Learning contributes nine micro-credential articles, representing approximately 1.87% of the total research on this topic. Following this, the proceedings of the International Conference of the LEA include seven articles (1.45%). At the same time, the IEEE Global Engineering Education Conference and the British Journal of Educational Technology each contribute five publications (1.04%), alongside Computers and Education, with five publications (1.04%). Regarding annual document distribution, the International Journal of Educational Technology in Higher Education consistently increases publications, particularly in 2022. The CEUR Workshop Proceedings similarly display a stable publication pattern with peaks in specific years, such as 2014, 2017, and 2019. Other sources like TechTrends and Education Sciences demonstrate more sporadic contributions, yet they have maintained a significant impact in recent years. These sources serve as key platforms for disseminating micro-credential research, highlighting high interest among academic conferences and journals, with a primary focus on educational technology, technical education, and applied learning. Collectively, these platforms contribute around 18.98% of all publications on this topic, solidifying their role as central outlets for advancing research on micro-credentials.

The micro-credential research trend reveals broad international engagement, reflecting a global focus on flexible education models responsive to labour market needs. Micro-credentials, which emphasize specific, applied skills, have captivated researchers and institutions worldwide, motivating efforts to understand and develop relevant, efficient learning models. This publication analysis identifies the most productive countries in micro-credential research, spotlighting key hubs of innovation and research within the field. Among the total 482 documents, several countries emerge with notable contributions, indicating their pioneering roles in developing and implementing micro-credentials to strengthen workforce skills to align with modern industry demands.

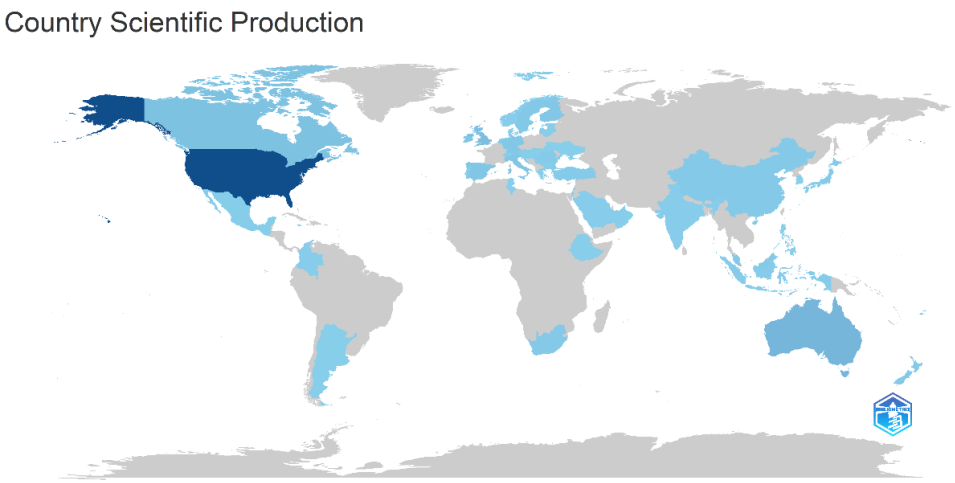

Figure 4. Most Productive Countries Conducting Research on Micro-Credentials

Based on the data from figure 4, the United States is the most productive country in generating micro-credential publications, with 212 documents accounting for 44% of the 482 total publications. This indicates that the United States is a major hub for micro-credential research, likely driven by the rapid advancement of educational technology and the rising demand for new skills within its industries. Australia ranks second with 38 documents, approximately 7.9% of the total publications. This position reflects Australia's significant focus on implementing and studying micro-credentials, especially within higher education, which increasingly incorporates practical skill development. The United Kingdom follows with 25 documents or 5.2%, underscoring its strong focus on flexible education and skill development tailored to the labour market's needs.

In summary, the concentration of micro-credential publications in these countries indicates a global trend towards aligning workforce skills with industry needs. It also showcases each country's active contributions to innovation and research in developing micro-credentials within higher education and industry settings. This global engagement reflects the growing interest in flexible, industry-relevant learning models as micro-credentials continue to gain traction worldwide.

Thematic Analysis

The thematic structure of micro-credential research was analyzed using VOSviewer's keyword co-occurrence mapping (Figure 5). This approach uncovered latent semantic patterns across publications, producing identifiable clusters that reflect the conceptual structure of the field. To prevent redundancy and ensure analytical depth, dominant keywords like "micro-credential" and "open badges" were excluded from clustering. The focus was directed toward supporting terms that reveal thematic evolution, pedagogical orientation, and technological integration within micro-credential frameworks. This approach uses co-word analysis to extract conceptual trends in scientific domains. By analyzing keyword clusters, this study reveals macro-level patterns and micro-level conceptual relationships in the MC literature (Zitt, 2015; Saxena et al., 2024).

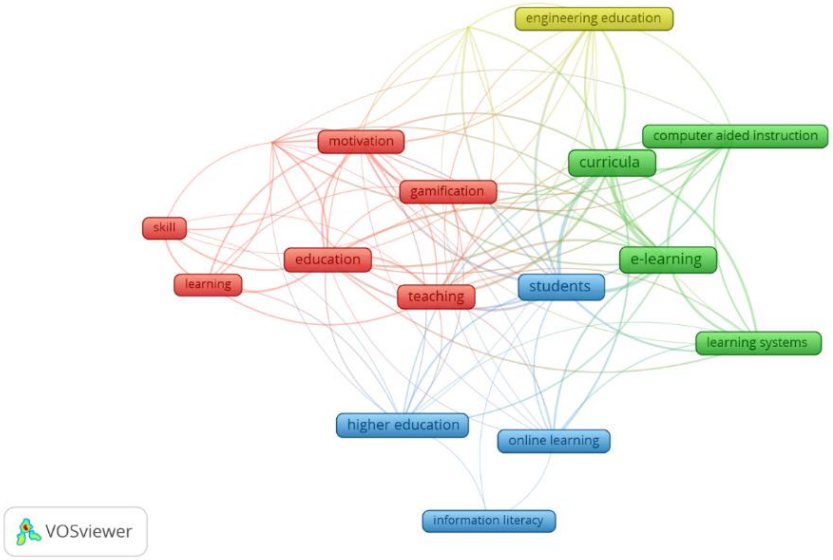

Figure 5. Keyword clusters of Micro-Credentials research from VOSviewer

Cluster 1 (Red) - Education and Motivation. The red cluster includes keywords such as "education," "motivation," "teaching", "learning", "skill", and "gamification". Its main focus is on the educational process, learning motivation, and skill development. Research in this cluster explores how teaching techniques, motivation, and gamification can impact student learning outcomes. For instance, gamification enhances student engagement and motivation by applying game elements within an educational context. This aligns with prior studies (Ellis et al., 2016), which argue that game-based interventions increase learning persistence and motivation, particularly in online micro-credentials where direct supervision is limited.

Cluster 2 (Green) - Curriculum and Computer-Aided Learning. The green cluster consists of keywords such as "curricula", "computer-aided instruction", "learning systems", and "e-learning". The central theme in this cluster is integrating technology in curricula and computer-aided learning. Topics like e-learning and computer-aided learning systems highlight the importance of technology in supporting a more flexible and adaptive educational process. This research often explores how curricula can be tailored to meet modern technological needs to enhance learning effectiveness. These findings resonate with Eibl et al. (2024), who emphasized the growing role of technology-integrated curricula in enhancing flexible delivery and personalization.

Cluster 3 (Blue) - Higher Education and Online Learning (Blue). The blue cluster encompasses keywords such as "higher education", "online learning", "students", and "information literacy". Its primary focus is higher education and online learning. Research in this cluster explores how online learning can optimize higher education and how information literacy is key in supporting student learning. Online learning platforms for higher education are increasingly vital, particularly in the context of education globalization and the need for greater accessibility. As supported by Hunt et al. (2020), digital micro-credentials facilitate skill validation in remote learning environments, increasing access and scalability for lifelong learners.

Cluster 4 (Yellow) - Engineering Education and Assessment. The yellow cluster includes keywords such as "engineering education" and "assessment". The main theme in this cluster is engineering education and learning assessment. Research in this cluster often explores how engineering education can be optimized through innovative assessment approaches and supportive technologies (Eager & Cook, 2020; Cook, 2021). This research also emphasizes the importance of proper assessment to ensure that student learning outcomes align with industry standards and labour market needs.

Program Structure and Learning Delivery Format

The structure of micro-credential programs is generally designed to provide flexibility and relevance to industry needs. These programs are often modular, allowing students to complete learning units in smaller, continuous modules (Januszak & Koorie, 2018; Gedeon, 2020; McGovern & Gogan, 2022; Smith & Kálmán, 2023). This modular structure facilitates lifelong learning integration into

professional careers, with each module focusing on specific skills required in the workplace. Micro-credential delivery formats, including fully online, blended learning, and hybrid models, vary widely. The fully online format allows participants to learn flexibly without geographical or time constraints, making it ideal for those needing self-directed learning access (Başal & Kaynak, 2020; Dennis & Halbert, 2022; Hou, 2023). The popularity of this format in micro-credential programs is largely due to the freedom it offers participants, especially professionals seeking to upskill without leaving their jobs. However, fully online formats have limitations in face-to-face interaction, which can affect learning experiences and engagement, particularly for skills requiring hands-on practice.

In contrast, blended learning is more prevalent in micro-credential implementation, combining online and face-to-face learning, offering flexibility and a more comprehensive learning experience. This model provides flexible material access while supporting direct interaction, both physical and virtual, thus optimally supporting engagement and mastery of practical skills (Littenberg-Tobias & Reich, 2018; Zhou et al., 2019; Eibl et al., 2024). However, blended learning faces challenges, especially in the need for adequate technology and instructor readiness to manage online effectively and face-to-face components (Eibl et al., 2024). Meanwhile, the hybrid format offers online, face-to-face, and independent activities, providing a more varied and interactive learning experience. This format's advantage lies in the flexibility and depth of interaction achieved through in-person and virtual meetings, allowing participants to interact directly with instructors and peers (Abramovich, 2016; Batool et al., 2023). However, hybrid models require sufficient technology infrastructure and schedule coordination, which can be challenging for participants and program providers.

In the context of micro-credentials, the blended format has proven effective in meeting diverse learning needs. Research shows that participants are more engaged and motivated when they have the opportunity to interact with instructors and peers directly, in addition to the flexibility offered by online components (Zhou et al., 2019). Similar findings by Kumar & Dawson (2022) reveal that this mixed approach enhances student engagement, retention of information, and acquired skills. This format also supports better integration of theory and practice, which is highly beneficial in developing specific skills needed in the workplace. Micro-credential programs based on blended learning have shown an increase in the practical application of skills compared to programs that use only online formats (Tamoliune et al., 2023). Overall, the dominance of the blended format in micro-credentials reflects an effort to combine flexibility with deep interaction in the learning process. This allows micro-credential programs to be more responsive to individual needs and ensures that acquired skills can be applied practically in the real world. These findings provide valuable insights for educational institutions in designing effective and efficient micro-credential programs.

These findings confirm the centrality of blended learning delivery as an effective pedagogical model that simultaneously enhances learner engagement and maintains high accessibility, making it particularly suitable for upskilling and professional development contexts. When generalized across disciplines, the evidence suggests that blended delivery may represent a best-practice framework in the design of micro-credential programs. Importantly, this has practical implications for educational institutions and policy-makers, particularly in guiding resource allocation, such as investment in virtual laboratories, interactive platforms, and faculty training, toward elements that directly impact learner satisfaction and success. Nevertheless, the widespread adoption of blended models also reveals a critical limitation: the implicit assumption that both learners and institutions possess adequate access to digital tools and in-person learning facilities. In regions marked by technological disparities or limited infrastructure, such models may not be equitably implementable, thereby necessitating adaptive, context-sensitive strategies. Therefore, future research should explore the efficacy of blended delivery in diverse sectoral contexts, such as healthcare, education, and STEM, and assess how learner outcomes vary according to demographic indicators including age, employment status, and digital readiness, to ensure inclusive and effective micro-credential implementation.

Learning Model

The learning models used in micro-credentials encompass various approaches tailored to the needs and contexts of education. Some commonly used learning models in micro-credentials include Project-based Learning (PBL) (Cook, 2021; Sousa-Vieira et al., 2022); self-directed Learning (Kumar et al., 2022); problem-based Learning (O'Keeffe et al., 2022), and Game-based Learning (Sun et al., 2023). Each model offers unique advantages that can enhance students' skills and knowledge. Project-based learning (PBL) is where students actively engage in meaningful and relevant projects. This model emphasizes applying knowledge and skills in real-world situations. Research by Cook (2021) and Sousa-Vieira et al., (2022) indicates that PBL effectively develops students' critical and collaborative skills. Additionally, PBL allows students to work on projects directly linked to industry needs, thereby increasing the relevance of learning and job readiness (O'Keeffe et al., 2022). This is also supported by Gauthier (2020), which states that from an industry perspective, MCs should focus on project-based tasks to help future employees better understand how the industry operates. Therefore, project-based learning is one of the most widely adopted micro-credential models.

The widespread adoption of PBL in micro-credentials reflects the increasing demand for experiential learning approaches that simulate workplace tasks. Compared to conventional content delivery, PBL fosters a stronger connection between theoretical knowledge and hands-on competencies, thereby enhancing employability. Its emphasis on real-world application is especially critical in fast-evolving sectors like technology, where continuous skill upgrading is essential.

The next model is self-directed learning, emphasizing students' responsibility in organizing and managing their learning process. Self-directed learning can boost students' motivation and engagement as they have full control over their learning (Zhu et al., 2022). It allows students to learn at their own pace and style, significantly improving learning outcomes. Furthermore, as most MCs utilize online learning, personalization becomes a major advantage in MCs, supporting self-directed learning that focuses on students' abilities and interests (Hunt et al., 2020). From a learner autonomy perspective, self-directed learning aligns with adult learning principles (andragogy), promoting ownership and intrinsic motivation (Gupta et al., 2024). This approach is particularly relevant in micro-credential contexts where learners are often professionals with specific learning goals and time constraints. In addition, by supporting asynchronous access and personalized pacing, self-directed learning increases accessibility for diverse learners, including part-time workers and remote participants.

Problem-based Learning (PBL) is an approach that challenges students to solve real, complex problems. Nallaluthan et al., (2023) found that PBL enhances students' problem-solving and critical-thinking skills. This model encourages students to work in groups, identify issues, gather information, and develop solutions, all vital workplace skills. PBL leverages scenarios that may occur in the field or under actual conditions, which helps students develop transferable skills (Sousa-Vieira et al., 2022), making it a common choice in MCs aimed at skill development. The emphasis on scenario-based, collaborative inquiry within PBL provides an ideal model for preparing learners to navigate complex, ill-defined challenges in the modern workplace. When compared to other models, PBL offers a higher cognitive load that promotes deeper learning, especially in fields requiring diagnostic reasoning, such as healthcare and engineering.

Game-based learning uses game elements and mechanics to enhance students' motivation and engagement. Fedock et al., (2016) found that game-based learning can make education more engaging and enjoyable. Moreover, game-based learning can enhance students' cognitive and affective skills through stimulating challenges and instant feedback (Sun et al., 2024). Game-based learning has the potential to provide interactive and promising learning experiences through e-learning technology, allowing for a variety of features. Although not as widely adopted as PBL or self-directed learning, game-based learning holds significant potential for increasing learner engagement and knowledge retention, particularly among younger or novice learners. The use of gamification in micro-credentials may also promote competitive and reward-based motivation mechanisms, which are useful in short-term learning cycles. However, further empirical studies are needed to assess long-term skill transferability and scalability in professional learning contexts.

Overall, the variation in learning models used in micro-credential programs reflects an intentional pedagogical shift toward learner-centered, competency-based education. When aligned with learner profiles and sectoral demands, these models enhance engagement, personalize learning pathways, and improve practical skill acquisition. Future research should explore the comparative effectiveness of these models across fields, such as health, education, and IT, and identify which combinations yield optimal

learner outcomes, particularly in hybrid and asynchronous settings. It is also recommended to assess the role of learning analytics and adaptive technologies in supporting personalized implementation of these models.

Assessment and Evaluation

Assessment and evaluation in micro-credentials are designed to measure the specific competencies achieved by learners. Competency-based evaluation approaches directly assess the relevant skills acquired and are considered more effective than traditional exam-based evaluations (Alamri et al., 2021). This assessment can be conducted through a final project, allowing students to practice and apply the skills they have learned in a real-world context (Maina et al., 2022). Additionally, the use of portfolios as a form of evaluation is also popular in micro-credentials, where portfolios serve as evidence of mastered skills and the learning experiences acquired by participants (Hunt et al., 2020; Varadarajan et al., 2023).

The grading system applied in micro-credentials also includes the use of specific rubrics to measure the skills developed within the program, along with constructive feedback that supports improvement (Heinert et al., 2021). Direct feedback from experts through focused group discussion (FGD) sessions is another increasingly adopted approach in micro-credentials to ensure that participants receive evaluations from specialists in their field (Steyn & Eybers, 2023). This evaluation approach better reflects students' ability to apply the knowledge they have previously learned. Since micro-credentials focus on skill development and training, direct assessment of students' practical skills is more effective, such as certification processes (Reed, 2023) and skills assessments (Hickey, 2016).

These findings demonstrate a clear shift in micro-credential assessment toward more authentic and context-driven models, reinforcing the centrality of experiential learning and workplace relevance. Compared to traditional exam-based evaluations, the use of final projects, portfolios, and competency rubrics is better aligned with the principles of adult learning and industry standards. Generalizing from these observations, it can be inferred that micro-credentials emphasizing performance-based assessments are better positioned to support job readiness and enhance learner credibility in the labor market. However, these approaches also reveal certain limitations, such as the high resource demands for expert-led evaluations and potential inconsistencies in rubric interpretation across institutions. Future research is warranted to investigate how assessment types influence learners' long-term skill retention, self-efficacy, and employability, especially across different socioeconomic and professional backgrounds. These insights would be instrumental in shaping inclusive and sustainable assessment ecosystems within micro-credential frameworks.

Industry Engagement

Industry involvement is a crucial component in the development and implementation of micro-credentials. This engagement helps ensure that the programs offered align with labour market needs (Hoanca et al., 2019; Ponte & Saray, 2019; Ruddy & Ponte, 2019; Marriott & Martinez-Marroquin, 2021; Ralston, 2021; Venugopal et al., 2021; Zouri & Ferworn, 2021; Bagiati et al., 2022; Lau et al., 2022; Langseth et al., 2023; Morrey, 2023; Pandey Rajesh Kumar & Hetvi, 2023; Vidric et al., 2023). The primary focus of micro-credentials is to provide a platform that enhances students' skills in line with workforce requirements. Industry involvement can take various forms, including collaboration with higher education institutions or MC providers in curriculum and assessment design (Felton et al., 2023; Laundon et al., 2023; Varadarajan et al., 2023), supplying learning materials (Zhou et al., 2019), and defining the skills and qualifications required in the professional world (Caetano et al., 2023; Joyner, 2016; Laundon et al., 2023). Additionally, industries may provide internship opportunities for students to practice their acquired skills, participate in evaluations, and engage in various other forms of collaboration (Bowles et al., 2023). Partnerships with companies and professional organizations support MC providers in designing curricula that meet industry standards while offering internships or real-world projects that enrich students' learning experiences, ultimately ensuring that learning objectives are met.

The findings reaffirm that industry engagement is not merely complementary but foundational to the relevance and success of micro-credential programs. This alignment between curriculum design and real-world skill requirements mirrors the importance of co-creation between academia and industry for enhancing program impact and learner employability. Compared to conventional academic models, micro-credentials supported by industry show stronger workforce alignment, particularly in fast-evolving fields like digital technologies, health, and sustainability. From a broader perspective, this trend suggests

that structured industry-academic partnerships can serve as a scalable model for workforce-responsive education. However, the degree and quality of industry participation remain uneven across regions and disciplines, often influenced by institutional readiness and sectoral maturity. This reveals a limitation in generalizing best practices universally, especially in emerging economies where such ecosystems are underdeveloped. The future studies should investigate context-specific models of industry integration and assess the outcomes of varying partnership intensities on learner performance and employment pathways.

Skill Areas in Micro-Credentials

Micro-credentials often focus on specific skills required in the workplace. Micro-credential programs are generally practical and application-based, designed to provide a competitive edge in the job market. There are at least eight skill groups that commonly serve as focal points in micro-credential programs. The computer and digital skills group encompasses abilities such as data analysis (Venugopal et al., 2021; Kiiskilä et al., 2023). This area also includes information digital competencies (McGreal et al., 2022). As technology rapidly advances, the demand for digital skills in the job market continues to rise, making these skills one of the primary competencies that are highly valued (Morrey, 2023). Additionally, Literacy and Library Skills focus on the use of information and library services, encompassing customer service for librarians (Goulding & Campbell-Meier, 2024). This skill set also includes lifelong learning (Smit et al., 2024) and academic integrity awareness (Hossain et al., 2024). Literacy in this context aims to enhance workplace effectiveness by fostering a deeper understanding of digital media usage and information literacy skills.

In the area of health skills, offered courses cover various health aspects, including mental health (Epstein et al., 2024), nursing (Shay, 2023), pharmacy (Lok et al., 2022), public health (Dysart et al., 2021), and health advocacy (Mashford-Pringle et al., 2023). The implementation of micro-credentials in healthcare allows medical students to gain valuable practical experience, enabling them to apply theoretical knowledge (Peisachovich et al., 2021). In the field of economics and business skills, the taught competencies include finance (Batool et al., 2023). These skills are crucial in the global job market as they help individuals compete effectively abilities that are increasingly sought after across industries (Srinivasan & Thangaraj, 2021)

STEM Skills cover technical abilities (Davis-Hall et al., 2023), and mathematics (Cook, 2021). STEM skills are increasingly viewed as essential 21st-century competencies, as they enhance workforce competitiveness across various industrial sectors (Lavi et al., 2021). Additionally, interpersonal, social, and soft skills are widely developed through micro-credentials to improve communication and collaboration abilities that align with industry needs (Maina et al., 2022). These interpersonal skills are essential for effective teamwork and professional interactions in the workplace. Employability Skills include various micro-credential courses that help participants enhance fundamental skills needed in the workplace, thereby increasing their employability. Educational Skills are designed to prepare prospective teachers to enter the education field, with a focus on competency-based interdisciplinary learning (Chandler & Perryman, 2023; Tamoliune et al., 2023). Micro-credential programs related to this skill set often focus on developing competencies that are relevant to workforce demands, both for students entering the workforce and for employees looking to upgrade their skills.

This thematic distribution of skill areas illustrates the responsiveness of micro-credential programs to both current and emerging labor market demands. Compared to traditional degree pathways, micro-credentials demonstrate stronger alignment with applied skill acquisition, as shown by the emphasis on digital, STEM, and interpersonal competencies. The consistent presence of employability and interpersonal skills across diverse programs suggests that micro-credentials are increasingly viewed as vehicles for holistic professional development, not merely technical upskilling.

From a broader perspective, this skill clustering implies that micro-credentials function as modular labor market signaling tools, enabling learners to curate individualized pathways to employment or promotion. However, the contextual disparity in skill focus, such as the dominance of digital skills in high-income regions versus health or education skills in lower-income settings, highlights the importance of localized curriculum design and institutional adaptability. While practical applications of micro-credentials continue to evolve, the academic literature remains conceptually fragmented, with limited synthesis linking their theoretical foundations, learning models, and targeted skill domains across sectors. This gap in integrative understanding hinders the development of a coherent framework that explains how micro-credentials are structured, delivered, and aligned with industry or educational outcomes.

A notable limitation in the current body of evidence is the absence of longitudinal research tracking the impact of certified skill areas on real-world outcomes. Specifically, little is known about how micro-credentials influence job placement, income mobility, or career progression over time. To address this, future studies should examine sector-specific outcomes and assess how stacking multiple micro-credentials affects long-term employability and professional resilience.

CONCLUSION

Micro-credentials, as an alternative learning option, are frequently discussed by researchers. One of the advantages of micro-credentials is their competency-based approach, which helps students focus on practical skill development. Given the numerous potentials of micro-credentials, more universities are offering their own micro-credentials programs. This has expanded the available training fields, including computer and digital skills. However, micro-credentials can be applied to other areas of study as well. In line with the objectives of this study, the research has successfully mapped the development trajectory, delivery models, and skill domains associated with micro-credentials, while also identifying key patterns in performance and conceptual trends through bibliometric analysis. The synthesis of findings suggests a broader conceptual proposition: micro-credentials are evolving not merely as supplementary learning instruments but as foundational elements of an emergent credentialing ecosystem that emphasizes modular, job-relevant competencies. This reflects a theoretical shift in credential recognition, moving away from traditional, monolithic degree structures toward more flexible, micro-unit qualifications that can be accumulated and demonstrated over time.

The implications of this transformation are twofold. First, at a practical level, higher education institutions are encouraged to align their micro-credential offerings with industry-endorsed skill requirements to enhance graduate employability and foster lifelong learning adaptability. Second, at a theoretical level, future scholarship should advance the concept of "credential ecology," focusing on the transferability, stackability, and integration mechanisms between micro- and macro-credential systems, thereby contributing to a more dynamic and responsive learning architecture across education and employment sectors.

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CONFLICTS OF INTEREST

The author(s) declare no conflict of interest.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

The authors declare that no artificial intelligence (AI) tools were used in the generation, analysis, or writing of this manuscript. All aspects of the research, including data collection, interpretation, and manuscript preparation, were carried out entirely by the authors without the assistance of AI-based technologies.

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