Micro-credentials in higher education: a review and bibliometric

Riche Cynthia Johan[1], Gema Rullyana[1], Rudi Susilana[2], Mario Emilzoli[2]
[1]Department of Library and Information Science, Faculty of Education, Universitas Pendidikan Indonesia, Bandung, Indonesia
[2]Department of Educational Technology, Faculty of Education, Universitas Pendidikan Indonesia, Bandung, Indonesia

Article Info

ABSTRACT

The objective of this study is to conduct a comprehensive review of research on "Micro-credentials in higher education" by doing a bibliometric analysis of 85 journal articles published between 2015 and 2023, obtained from the Scopus database. This study focuses on quantifying the number of publications and citations, as well as examining subject areas, connections, universities, countries, and identifying the most productive and prominent researchers. Apart from that, this research also identifies research topics that researchers have been working on in recent years. The findings show that publications and citations have increased in the last three years. The United States, Australia, and Canada are the most productive countries on this topic. T. J. Newby is the most productive researcher, while the most influential writer is D. -K. Mah. TechTrends and The International Journal of Information and Learning Technology are the journals that publish the most research. The university that made the top contribution was Purdue University (United States). The results of data analysis show that collaboration between authors researching "Micro-credentials in higher education" still needs improvement. This research contributes as a basis for further research in enriching and developing knowledge about micro-credentials, especially in higher education.

Corresponding Author:

Riche Cynthia Johan
Department of Library and Informastion Science, Faculty of Education, Universitas Pendidikan Indonesia
St. Dr. Setiabudhi No. 229, Bandung 40154, Indonesia
Email: riche@upi.edu

1. INTRODUCTION

The very rapid development of technology poses challenges to the flexibility of the existing education system. The education system owned by educational institutions needs to be improved to make it possible to offer micro-credentials via online platforms. Micro-credentials are the latest educational trend as developments in digital technology change the way learning and teaching become more effective [1]–[3]. Micro-credentials are built on discourse about the changing role of higher education in the 21st century. To address labor market demands, new skills are offered, and services are expanded for evaluating and recognizing prior learning experiences [4]. Moreover, today, entrepreneurs are eager to invest in human resources [5], [6].

Based on this perspective, micro-credentials are not intended to replace traditional higher education methods. Instead, they aim to introduce innovative approaches to professional development, recognition, and assessment of prior learning [7], [5]. Educational institutions are now given a new role as organizers of micro-credentials in the education ecosystem [8], [9]. It is essential to be more accurate in micro-credentials and realize that it is not only oriented toward the output produced. But it must also investigate the challenges and risks that can arise. Therefore, micro-credentials advance by entering a persuasion phase, during which stakeholders reassess the benefits and challenges of implementing this approach [5], [10].

Along with this growth, quite a number of researchers are interested in conducting studies on micro-credentials. Micro-credentials are increasingly popular among academics and practitioners in the education sector [11], [12]. Several previous studies related to micro-credentials have been identified. Previous research analyzed bibliometric approaches with the theme of implementing micro-credentials in higher education [13]. The research findings suggest that micro-credentials in higher education are attracting considerable interest from the academic community. Although researchers have examined different aspects of the topic using various methods and theories, more research is needed to grasp how technology affects different stakeholder's perspectives entirely. Furthermore, this study emphasizes the need to address critical areas of research that are necessary for the advancement of the existing body of knowledge on the implementation of micro-credentials in higher education.

Other research that examines Massive Open Online Courses (MOOCs) using a bibliometric approach to identify research trends, journals, regions and institutions with a high H index, scientific collaborations, research topics, distribution of issues in countries/regions, productive institutions, and distribution of subjects used in MOOCs [14]. Between 2008 and 2019, 1,788 publications were sourced from three significant databases: Web of Science (WOS), Scopus, and Education Resources Information Center (ERIC). This bibliometric analysis offers researchers a detailed and comprehensive overview of current MOOC research, pinpointing emerging research topics and identifying potential collaborative partners for future MOOC-related investigations.

In addition, another study investigated online learning in higher education around the world during COVID-19 using bibliometric analysis [15]. The researchers employed co-citation analysis and text mining facilitated by VOS viewer to collect and analyze research patterns and subjects discussed in peer-reviewed documents published from January 2020 to August 2021. The study reveals that researchers from 103 countries or territories across the globe conducted investigations on a range of subjects, including the utilization of diverse technologies and learning approaches, curriculum restructuring, student perspectives, and the psychological consequences of online learning resulting from the pandemic. This study also examines online higher education's present and upcoming difficulties, prioritizing the implementation of creative teaching methods in online learning. Additionally, it acknowledges the increasing but uneven availability of literature related to these research findings.

Bibliometric analysis is a quantitative method for studying and analyzing a scientific publication. This method uses various statistical indicators to map research trends, identify collaborations between researchers, and assess the impact of research. Regarding bibliometric analysis of micro-credential studies, as far as we know, there has yet to be any research on micro-credentials that analyzes science and mapping performance in recent years. So, this research investigates studies on micro-credentials in the 2015-2023 period using the Scopus database. Then, previous bibliometric research only focused on implementing micro-credentials in higher education. This is a gap in this research, so researchers aim to analyze research trends regarding Micro-credentials through bibliometric analysis. This analysis encompasses both performance analysis and science mapping. This research contributes to the field by providing an overview of the growth of MOOC research over the past five years and serves as a comprehensive reference for other researchers studying micro-credentials in higher education.

2. METHOD

The bibliographic method was employed in this study. The bibliometric approach applies quantitative approaches to analyze scientific literature [16], [17]. The data source for this work is the Scopus database. Scopus, one of the top scientific databases, enjoys great credibility for offering thorough and high-quality scientific data [18], [19]. This research analysis has two main components: i) the use of bibliometric mapping to study trends in micro-credentials in higher education, and ii) the analysis of indexed keywords in publications to identify research clusters and gain insights into research themes associated with micro-credentials in higher education. The research uses VOS viewer software to facilitate data interpretation trenchwork, overlay density visual visualizations. These visualizations readability and comprehension. Software like VOS viewer can offer insights into network metrics and clustering, which are valuable for bibliometric study studies [20], [21]. There are 5 bibliometric analysis steps used in this research, as presented in Figure 1 [22]–[24].

2.1. Defining search keywords

In bibliometric studies, selecting search keywords is very important because these keywords are the basis for identifying, extracting, and analyzing relevant literature. The keyword search selected to be used in the literature search in the Scopus Database carried out on September 4, 2023, was "micro-credentials" OR "micro-credential" OR "digital badges" OR "virtual badges" AND "higher education". As an initial step, the

researcher selected document features in the Scopus database; then, these keywords were written in the subsection of the document feature, namely "document search," with a choice of search formats "article title," "abstract," and "keyword".

Figure 1. Bibliometric steps analysis

2.2. Initial search results

The search yielded 184 documents suitable for "micro-credentials in higher education" sourced from Articles, conference paper, book chapter, conference review, review, book, editorials, erratum, and all languages. These documents were also output without using a time range setting. This comprehensive data set provides a strong foundation for conducting bibliometric analysis.

2.3. Refining the search results

Several specific criteria were established to obtain documents suitable for this research. First, the document title contains the keywords "micro-credentials" OR "micro-credential" OR "digital badges" OR "virtual badges" AND "higher education". Second, the document is written in English. Third, the documents are derived from reputable journal and article sources. Moreover, the records that were released between the years 2015 and 2023. The process of systematically selecting documents that meet the inclusion criteria is accomplished through four sequential steps: i) identification, ii) screening, iii) eligibility, and iv) inclusion [16], [25]. Figure 2 presents details of these four steps. Based on Figure 2, there were 85 articles related to micro-credentials in higher education sourced from journal article document types, in English, published in the 2015-2023 period.
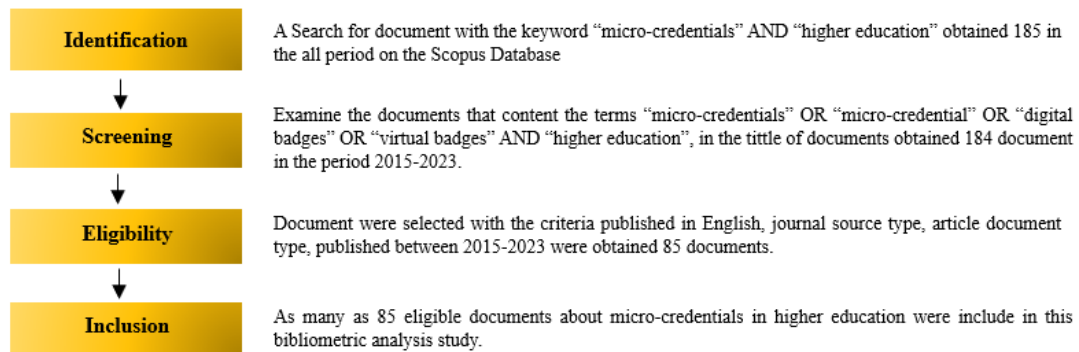
Figure 2. Steps in refining the search result of bibliometric analysis related to "micro-credentials in higher education"

2.4. Compiling the initial data statistics

Documents that satisfy the criteria are then employed as a research data source. The data was acquired from the Scopus database in two formats: comma separated values (CSV) and research information system (RIS). Both types provide crucial article details, such as bibliometric and bibliographic metadata [26]–[28].

2.5. Analyzing the data

The data analysis in this research involves conducting performance analysis and science mapping. The bibliometric meta-data was analyzed using VOS Viewer software to examine co-authorship data, bibliographic merging, keyword occurrences, and citations. Bibliographic coupling involves determining the relationships between items such as publications, journals, and authors by considering the number of shared resources. Examining the frequency of keywords provides insights into the patterns and developments within a particular area of research as time progresses [29]. Therefore, the bibliometric approach is efficient for

identifying trends in certain research fields. Citation analysis helps researchers detect popular research topics that other researchers are working on [30]. The results of the analysis are then presented in the form of a table or network visualization map.

Figure 3 shows that the development of publications, both the number of publications and citations related to micro-credentials in higher education is relatively constant from the period 2015 to 2017, and starting in early 2018 until 2023 the number of citations relatively increases, while the number of publications remains relatively constant up to in 2020. Furthermore, we can observe an increase in the number of publications from 2021 to 2023. Furthermore, the average number of publications per year is 9.4, while the average number of citations per year is 91.4. This data informs us that there is a positive correlation between the number of publications and citations related to micro-credentials in higher education, meaning that the greater the number of publications, the more citations [31].
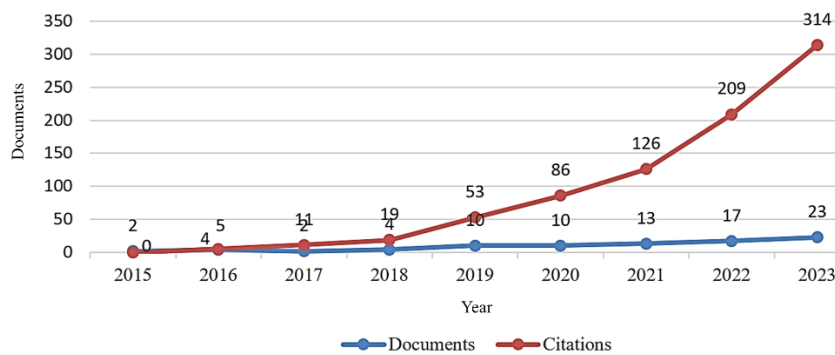
Figure 3. The development of publication and citation of research about micro-credentials in higher education

Figure 4 shows the distribution of publications by countries, publications on "micro-credentials in higher education" cover 26 countries. Researchers obtained data on the 10 countries with the top number of documents, namely the United States, in first place with 34 publications. The second place is occupied by Australia with a total of 14 publications, third is Canada with a total of 9 publications, fourth is the United Kingdom with a total of 5 publications, Germany and Spain with a total of 5 publications for each country. Meanwhile, China, Finland, and New Zealand each produced 2 publications.
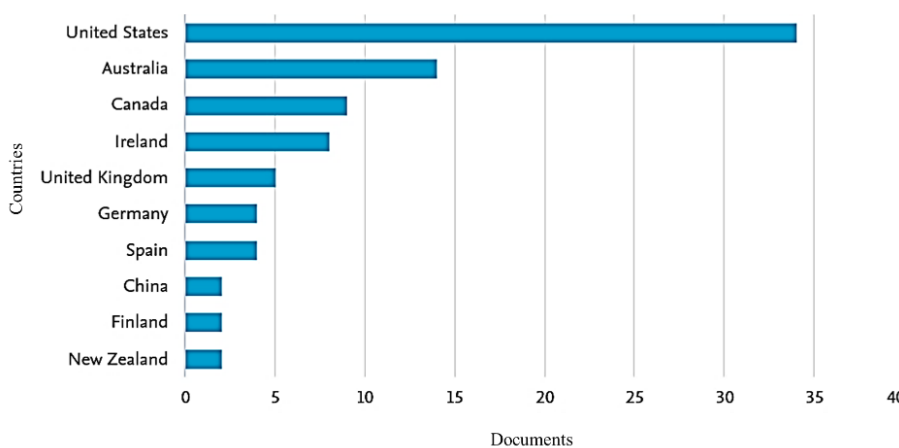
Figure 4. Publication on micro-credentials in higher education research according to countries

Figure 5 shows the research area subjects interested in micro-credentials in higher education. Among these subject areas, "social science" is the top subject area producing 54.2% of publications between 2015 and 2023. Furthermore, the subject area "computer science" is in second place producing 23.9%, in third place is

the subject area "business, management" produced 5.6%, in fourth place the subject area "medicine" produced 2.8%, while the subject area "mathematics" which was in fifth place produced 2.1%.
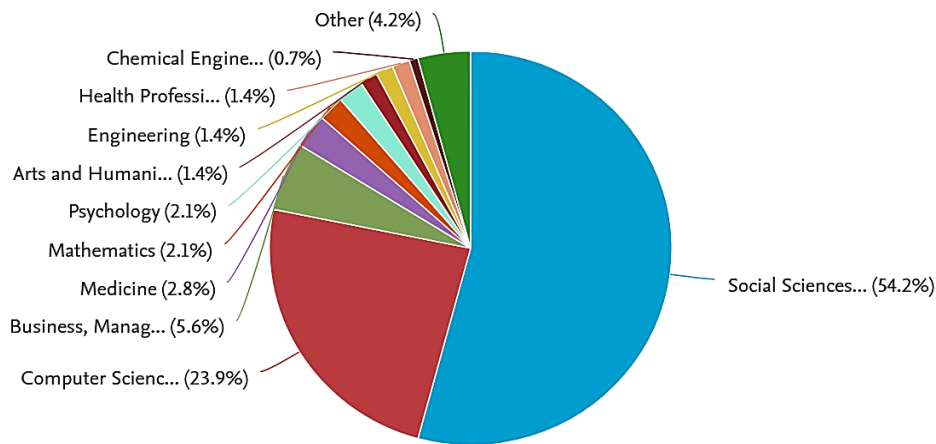
Figure 5. Publication micro-credentials in higher education according to research areas

We can observe the universities that made the top contribution in Figure 6. Among these universities, Purdue University (United States) is the top university that has contributed related to "micro-credentials in higher education" with a total of 6 publications. In second place, Dublin City University (Ireland) with 4 publications. The third to fifth directors with 3 publications each include the University of Toronto (Canada), Athabasca University (Canada), Universitat Potsdam (Germany). Meanwhile, in sequence, the University of South Africa (South Africa), University Oberta de Catalunya (Spain), University of Limerick (Ireland), Tempere University (Finland) and Norges Teknikk-Naturvitenskapeli (Norwegian) with a total of 2 publications.
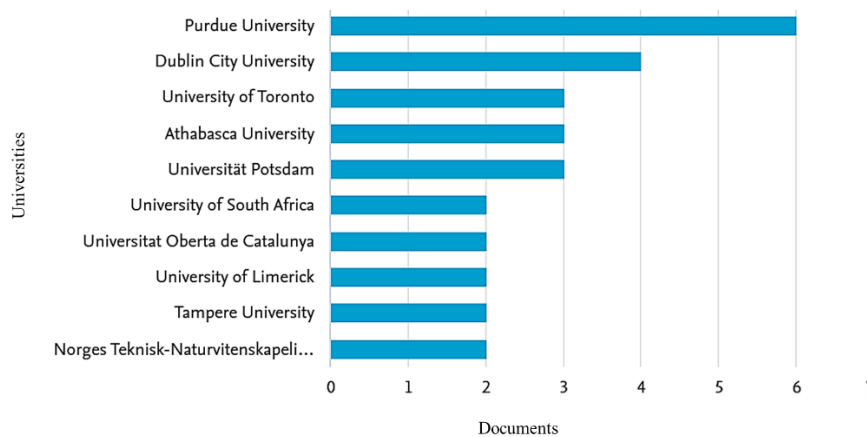
Figure 6. Publication micro-credentials in higher education according to universities

3.   RESULTS AND DISCUSSION
3.1. Co-authorship analysis
Co-authorship analysis is a science mapping technique that assumes publications that are frequently cited together have similar themes [32], [33]. This technique is basically used to present social interactions between authors related to a particular research topic [34]. The results of the analysis can be used to measure the quality of the structure in a particular research field [35], for example the underlying topic [36]. In co-authorship, two publications are connected when they appear together in the reference list of another publication, apart from that, through co-authorship analysis researchers can also find influential researchers in a particular field [16]. Co-authorship can also be interpreted as a form of research collaboration involving

several parties such as researchers, institutions, organizations and society [37]. Collaboration between researchers in each scientific discipline has different levels. The more often authors collaborate, the greater the collaboration in terms of research that can be achieved [38], [39]. Differences in the level of collaboration between scientific disciplines can be influenced by several factors, such as demographics, researcher information behavior, and gender [40], [41].

During the 2015-2023 period, 160 authors contributed to this research topic, either singly or in collaboration. Figure 7 shows a network visualization of co-authorship, marked with circles representing researchers, and the network represents relationships between researchers. The data results show that 160 authors have written at least 1 article, divided into 82 clusters with different colors. The results of the co-authorship analysis are centered on Jr. Don Olcott, who is a professor at the University of South Africa, Oldenburg University, and is active in conducting research in the field of micro-credentials. The network shows that there is a relationship, including with McGreal. The connection between the links shows that the authors conducted research together, and the stronger the relationship between the authors, the larger the circle formed. The visualization graph shows that most of the authors are not connected because they do not collaborate with each other. A collection of circles without a network appears to dominate so that we can interpret that research collaboration on the topic of micro-credentials in higher education is still very small. This is certainly a challenge and opportunity for researchers to build collaboration. Collaborative research can empirically improve research quality [42], articles tend to be cited more when they have more authors [42]–[45]. Apart from that, collaborative research can also improve the quality of an organization's research, the more collaborative research there is, the quantity and quality of the institution's research will also increase [42].
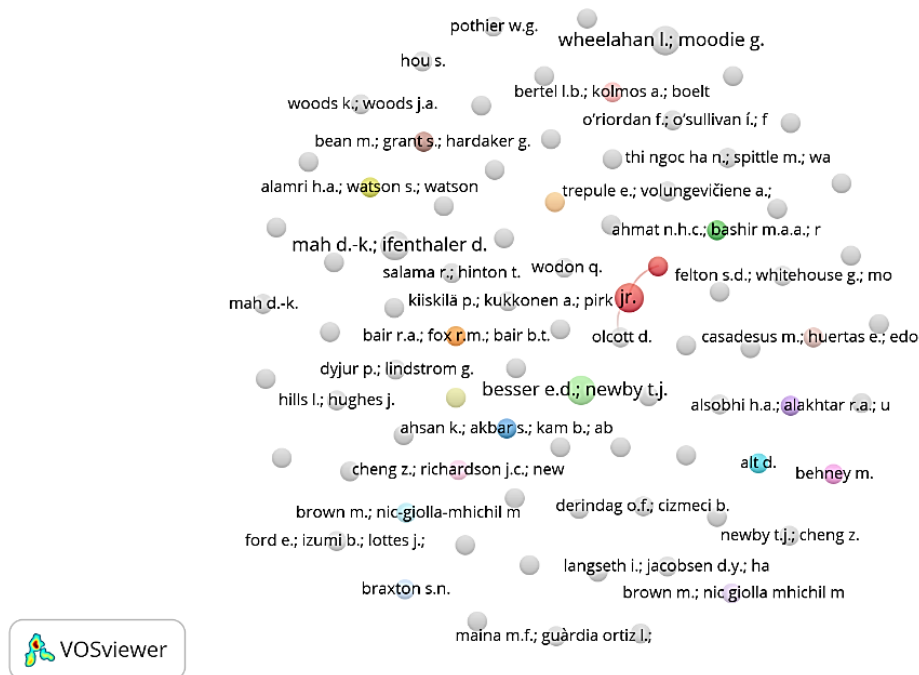
Figure 7. Co-authorship network map in micro-credentials in higher education

3.2. Most influential researchers

The number of publications is used to indicate influential documents, while the number of citations is used to indicate influential authors and sources. First, influential documents are represented by the top 10 documents with the highest citations obtained from the Scopus database, as we can see in Table 1. Table 2 shows that the most influential document related to the micro-credentials in higher education study was written by D. -K. Mah in 2016 with the title Learning Analytics and Digital Badges: Potential Impact on Student Retention in Higher Education [46]. This document has been cited by other relevant research 81 times. An example is Alamri et al. [47] with the title Learning Technology Models that Support Personalization within Blended Learning Environments in Higher Education. Furthermore, productive authors are represented by the top 5 authors with the highest publications while influential authors are represented by the top 5 authors with the highest publications.

Table 1. Most influential researchers in micro-credentials in higher education ranked by cites

No	Year	Authors	Title	Source	Cites	Publisher
1	2016	Mah [46]	Learning analytics and digital badges: potential impact on student retention in higher education	Technology, Knowledge and Learning	81	Springer
2	2021	Alamri et al. [47]	Learning technology models that support personalization within blended learning environments in higher education	TechTrends	47	Springer
3	2018	Carey and Stefaniak [48]	An exploration of the utility of digital badging in higher education settings	Educational Technology Research and Development	47	Springer
4	2017	Dyjur and Lindstrom [49]	Perceptions and uses of digital badges for professional learning development in higher education	TechTrends	42	Springer
5	2020	Facey-Shaw et al. [50]	Do badges affect intrinsic motivation in introductory programming students?	Simulation and Gaming	34	SAGE Publications Inc.
6	2018	Cheng et al. [51]	Goal setting and open digital badges in higher education	TechTrends	33	Springer
7	2021	Selvaratnam and Sankey [52]	An integrative literature review of the implementation of micro-credentials in higher education: implications for practice in Australasia	Journal of Teaching and Learning for Graduate Employability	25	Deakin University
8	2020	Newby and Cheng [53]	Instructional digital badges: effective learning tools	Educational Technology Research and Development	24	Springer
9	2021	Brown et al. [54]	The global micro-credential landscape: charting a new credential ecology for lifelong learning	Journal of Learning for Development	24	Commonwealth of Learning
10	2022	Wheelahan and Moodie [55]	Gig qualifications for the gig economy: micro-credentials and the "hungry mile"	Higher Education	24	Springer

Table 2. Most productive and influential researchers in micro-credentials in higher education

The productive authors			The influential authors		
Author	Institution/country	Total publication	Author	Total citation	Institution/country
T. J. Newby	Purdue University/USA	5	D. -K. Mah [46]	81	University of Potsdam/Germany
M. Brown	Dublin City University/Ireland	3	H.A. Alamri, S. Watson, and W. Watson [47]	47	King Saud University, Saudi Arabia
Z. Cheng	Purdue University/USA	3	K. L. Carey, and J. E. Stefaniak [48]	47	Old Dominion University, USA
D. -K. Mah	University of Potsdam/Germany	3	P. Dyjur, and G. Lindstrom [49]	42	University of Calgary, Canada
R. McGreal	Athabasca University/Canada	3	Facey-Shaw, L. Specht, P. M. van Rosmalen, and J. Bartley Bryan [50]	34	University of Technology Jamaica

Of the 160 authors involved in this research, T. J. Newby is the most productive author who has published 5 documents related to micro-credentials in higher education research affiliated with Purdue University (USA). One of the publications is entitled Instructional Digital Badges: Effective Learning Tools [53]. In the following positions, from second to fifth, there were the same number of publications, namely three. Brown et al. [54] occupies the second position; one of his publications is entitled A Strategic Institutional Response to Micro-Credentials: Key Questions for Educational Leaders. Cheng et al. [51] occupies the third position; one of his publications is entitled Goal Setting and Open Digital Badges in Higher Education. D. -K. Mah [46] occupies the fourth position. One of her publications is Learning Analytics and Digital Badges: Potential Impact on Student Retention in Higher Education. Next in fifth position is McGreal and Jr [2], with one of his publications entitled A Strategic Reset: micro-credentials for Higher Education Leaders. Meanwhile, the most influential writer regarding micro-credentials in Higher Education is D. -K. Mah [46] who is affiliated with the University of Potsdam (Germany). The document has been cited by other relevant studies approximately 81 times. Meanwhile, in second and third positions with the same number of citations are Alamri [47], who is affiliated with King Saud University (Saudi Arabia), and Watson [47] who is affiliated with Old Dominion University (USA), both of whom have been cited around 47 times.

3.3. Most influential journals

To determine the most influential journals that publish papers on micro-credentials in higher education, an analysis of the number of publications was carried out. Of the 49 journals, only 5 journals published at least 3 articles related to micro-credentials in higher education between 2015 and 2023. In Table 3, the journal with the highest number of publications is "TechTrends" with 6 publications. Next, the journal "International Journal of Information and Learning Technology" with 5 publications. Other journals "Australasian Journal of Educational Technology," International Journal of Educational Technology in Higher Education" and "Technology Knowledge and Learning" both have 3 publications. Observations in Table 3 show that "TechTrends" is the most influential journal regarding topics related to micro-credentials in higher education.

Table 3. Most influential journals in micro-credentials in higher education

No	Journal	Publication
1	TechTrends	6
2	International Journal of Information and Learning Technology	5
3	Australasian Journal of Educational Technology	3
4	International Journal of Educational Technology in Higher Education	3
5	Technology Knowledge and Learning	3

3.4. The keywords analysis and micro-credentials in higher education trend topics

The dataset is examined with the VOS viewer program by choosing the data option "create a map based on text data" once it has been saved in CSV format with Scopus metadata. The objective is establishing a network or connection between phrases using textual data. The identification of term fields is established by the analysis of the title and abstract. The dataset is calculated using the full counting approach. The cooccurrence analysis demonstrates that the keywords are organized into six distinct clusters or groupings, as illustrated in Figure 8. The clusters contain keywords that offer insights into interconnected study subjects within the specified field of interest [56].

Figure 8. Network visualization map of keywords co-occurrence

Figure 8, a network visualization of co-occurrence, provides an explanation of the network or relationship between terms in a study on micro-credentials in higher education from 2011 to 2021. The Scopus database contains 85 articles, which can be categorized into 6 clusters. The hue of each keyword node distinguishes these clusters. Cluster 1 includes terms related to micro-credentials in higher education that have

been researched, namely alternative credential, case, change, covid, credential, design methodology approach, employee, Europe, example, future, government, individual, lesson, lifelong; learning, MOOC, MOOCs, open university, order, originality value, pandemic, qualification, society, stakeholders, and terms. Cluster 2 consists of ability, assessment, digital badge system, educator, engagement, feedback, framework, instructor, knowledge, mastery, open course, open recognition, partnership, policy, principle, professional development, recognition, selfcare, teacher, and teaching. Cluster 3 consists of terms such as curriculum, digital transformation, discourse, entrepreneur, faculty, form, information literacy, innovation, instruction, librarian, library, nature, online learning, open badge, open badges, outcome, project, and united states. Cluster 4 consists of terms such as academic competency, analytics, completion, data, demand, digital badges, educational technology, first year student, further research, intention, participant, perception, platform, practical implications, student retention, and support. Cluster 5 consists of terms such as author, awareness, help, campus administrator, college, effect, effectiveness, gamification, graduate, group, intervention, motivation, participation, performance, training, and understanding. Cluster 6 consists of the term's adoption, dbs, degree, digital credential, factor, heis, importance, msc, potential, and systemic literature review. Once the mapping has been identified using network visualization, the subsequent phase involves mapping and clustering micro-credentials in higher education research trends according to the research's publication year. The data from the overlay visualization depicted in Figure 9 might serve as a valuable resource for discerning and identifying the latest advancements in research on micro-credentials in higher education.

Using VOS viewer software, overlay visualization derived from bibliometric analysis using Scopus metadata offers a clear picture of how research subjects have evolved. This visualization utilizes color-coded nodes to represent keywords that indicate the year of publication. This enables researchers to observe the temporal patterns of the topics being studied. As an illustration, the term "alternative credentials" is shown by a node in a light green color, indicating that publications containing this keyword were explicitly published in the years 2022-2023. Another instance is the concept of "employer," which is represented by green nodes in the overlay visualization. This indicates that researchers in the field of micro-credentials in higher education will exclusively examine the phrase "employer" in the year 2023.

Figure 9. Overlay visualization map of keywords co-occurrence

Another instance is the keyword "assessment," which is represented by a dark purple node color. The term "assessment" is equivalent to micro-credentials. Evaluation is a method used to gauge student's achievement before receiving a digital badge. Developing suitable micro-credential assessments is crucial to preventing student frustration when finishing each session [1], [57]. Therefore, the keyword "assessment" was used much earlier by researchers in conducting research on micro-credentials. Next is bibliometric analysis using density visualization.

The visualization findings in Figure 10 reveal variations in density across different nodes, with specific locations exhibiting higher density than others. The yellow indicates a high saturation level of keywords, indicating that Scopus has extensively researched and indexed the topic. For example, the keywords "employer," "framework," "perception," and "MOOC" are some of the keywords that are often associated with micro-credentials, meaning that this area is an area that is touched upon a lot by researchers. Meanwhile, we also found that keywords such as "educational technology," "lesson," "government," and "alternative credentials" are some of the keywords marked by dark nodes and far from light nodes. These keywords are starting to emerge as keywords associated with micro-credentials, meaning this topic is an area that has not been touched upon by many researchers.

Figure 10. Density visualization map of keywords co-occurrence

Even though there is still relatively little research on the topic of "micro-credentials in higher education," especially in education, this is an opportunity for researchers to continue to develop this research trend through journal publications. As mentioned above, keywords such as educational technology still need to be connected with micro-credentials in higher education. On the other hand, educational technology as a field of science has an essential role in facilitating learning and improving performance through the creation, management and utilization of learning processes and resources [58]. Developing and implementing flexible learning programs such as micro-credentials is an opportunity and challenge in educational technology. Research into instructional design for micro-credentials can be very relevant and rewarding [59]. Investigating micro-credential reliability in measuring academic achievement, job skills, and career mobility would also provide invaluable information. Research on the quality standards applied to micro-credentials can guide administrators and users to select and evaluate programs that suit their needs. With educational technology's support, micro-credentials can increase accessibility, flexibility and personalization in education [60], [61].

Based on research findings, another keyword with great potential to be researched is a lesson. Lessons and micro-credentials have a close relationship because lessons are an integral part of the micro-credentials program. Lessons are designed to provide a structured and focused learning experience, allowing learners to develop the necessary skills and knowledge in a short time [7], [2]. Research on lessons in micro-credentials can discuss various aspects related to developing, implementing and evaluating learning in micro credential programs. Explore effective instructional design strategies for micro-credentials, including project-based, problem-based, and case-based learning. Research methods for developing learning materials appropriate for micro-credentials, including digital technology and online learning resources. Evaluate the effectiveness of active learning approaches in micro-credentials, such as the flipped classroom, cooperative learning, or experiential learning. Analyze the use of technology to support learning in micro-credential programs, including digital learning platforms, simulations, and games. Create an appropriate learning assessment framework to measure competency achievement in micro-credentials. Examining the role of collaboration between industry and educational institutions in designing and implementing lessons in micro-credentials. Evaluate the effectiveness and success of learning in micro-credentials programs, including the impact on

career advancement and student engagement. This research can provide valuable insight into how micro-credential learning can be designed and implemented to achieve optimal student learning outcomes.

Next is the keyword governance. Visualization findings show that the keyword government has the potential for further development due to its low occurrence rate. The government has an important role related to micro-credentials [62], [12]. Researchers can explore several aspects of micro-credentials and the government. Studies could be conducted to evaluate the influence of government policy on the development, implementation, and recognition of micro-credentials, including an analysis of the impact of policies on accessibility, quality, and public acceptance of micro-credentials. Other research could explore the government's recognition of micro-credentials in formal and informal education systems. This includes the integration of micro-credentials into the curriculum, acceptance by educational institutions, and recognition in the selection or promotion process. Another topic that could potentially be explored is the role of government in identifying job market skills needs and guiding the development of relevant micro-credentials programs. This may include analysis of labor market needs, collaboration with industry, and development of appropriate skills programs. This research can provide insight into how the government can support developing and recognizing micro-credentials as an integral part of the national education and training system.

Alternative credentials are the next keyword that has great potential to be explored. Alternative credentials are a form of recognition of learning and achievements obtained outside traditional formal educational pathways, such as a bachelor's degree or diploma [63]. In the context of skills development and continuing education, alternative credentials and micro-credentials can complement each other to provide solutions that are more flexible and responsive to the needs of learners and the job market [64]. Research on alternative credentials can cover various aspects. Studies could explore the extent to which alternative credentials are accepted and recognized by stakeholders, including employers, educational institutions, and the general public. This includes an analysis of perceptions about the value of alternative credentials in meeting labor market needs. Through research in this area, we can better understand the role of alternative credentials in education and the job market and the factors that influence their development, recognition, and acceptance.

4.   CONCLUSION

The following can be concluded regarding the literature micro-credentials in higher education between 2015 and 2023 published by Scopus based on keyword analysis: i) The average annual publication rate is 9.4 articles; ii) The United States, Australia, Canada, Ireland, and the United Kingdom produced more publications on micro-credentials. Although the United States is one of the countries that publish more papers, it is not the country with the most influential researchers. Still, Germany produces the most influential researchers with the highest number of citations in publications, with researchers named D. -K. Mah and iii) Co-occurrence analysis highlights the lack of research on "educational technology," "learning," "government," and "alternative credentials." Based on the results of this data analysis, the number of studies on this issue has been relatively small in recent years.

This research has the following limitations: i) Scopus was the sole data collection tool used by the researchers, ii) Publications with in-press status were included in the research data, and iii) The terms micro-credentials, micro-credentials, digital badges, and virtual badges were associated with higher education during the data search, despite the fact that micro-credentials are not exclusively associated with higher education. Nevertheless, the data collection process is comparable because Scopus has recently published micro-credential studies. In future research, it is possible to integrate many approaches to conduct a theoretical analysis of micro-credentials. For instance, one may combine bibliometrics with systematic literature review (SLR) or SLR with meta-analysis. This research contributes by conducting a thorough keyword analysis to provide an overview of the existing literature on micro-credentials, particularly in higher education institutions.

REFERENCES

[1]   N. H. C. Ahmat, M. A. A. Bashir, A. R. Razali, and S. Kasolang, "Micro-Credentials in Higher Education Institutions: Challenges and Opportunities," *Asian J. Univ. Educ.*, vol. 17, no. 3, pp. 281–290, 2021, doi: 10.24191/ajue.v17i3.14505.

[2]   R. McGreal and D. O. Jr., "A strategic reset: micro-credentials for higher education leaders," *Smart Learn. Environ.*, vol. 9, no. 1, pp. 63–71, 2022, doi: 10.1186/s40561-022-00190-1.

[3]   D. Olcott, "Micro-Credentials: A Catalyst for Strategic Reset and Change in U.S. Higher Education," *American Journal of Distance Education*, vol. 36, no. 1, pp. 19–35, 2022, doi: 10.1080/08923647.2021.1997537.

[4]   J. Lang and K. Giglietta, "Implementing Continuing Professional Education Micro-Credentials in a University Context," in *Handbook of Research on Credential Innovations for Inclusive Pathways to Professions*, IGI Global, 2021, pp. 45–64. doi: 10.4018/978-1-7998-3820-3.ch003.

[5]   G. Tamoliune, R. Greenspon, M. Teresiviciene, A. Volungeviciene, E. Trepule, and E. Dauksiene, "Exploring the potential of micro-credentials: A systematic literature review," *Higher Education*, vol. 7, 2023, doi: 10.3389/feduc.2022.1006811.

[6]   M. Sufyan, W. Y. Degbey, R. Glavee-Geo, and D. B. Zoogah, "Transnational digital entrepreneurship and enterprise effectiveness: A micro-foundational perspective," *Journal of Business Research*, vol. 160, no. March, p. 113802, 2023, doi: 10.1016/j.jbusres.2023.113802.

[7]   L. Wheelahan and G. Moodie, "Analysing micro-credentials in higher education: a Bernsteinian analysis," *Journal of Curriculum Studies*, vol. 53, no. 2, pp. 212–228, 2021, doi: 10.1080/00220272.2021.1887358.

[8]   L. Acree, "Unwrapping Micro-credentials with the Chocolate Model of Change," *Driving Educational Change: Innovations in Action*, 2018. https://ohiostate.pressbooks.pub/drivechange/chapter/unwrapping-micro-credentials-with-the-chocolate-model-of-change/

[9]   M. Kohler, C. Gamrat, V. Raish, and E. Gross, "Microlearning and Micro-Credentials in Higher Education. In Microlearning in the Digital Age," in *Microlearning in the Digital Age*, London: Routledge, 2021, pp. 109–128. doi: 10.4324/9780367821623.

[10]   K. Yueh, I. F. B. Kamsin, and J. C. C. Fuh, "The Acceptance and Readiness of Micro-credentials and its Barriers in the Tech-related Job Market in Malaysia," in *Proceedings - International Conference on Developments in eSystems Engineering, DeSE*, 2023, pp. 190–195. doi: 10.1109/DeSE58274.2023.10099634.

[11]   M. Tooley and J. Hood, "Harnessing Micro-Credentials for Teacher Growth: A National Review of Early Best Practices," *New America*, 2021. https://files.eric.ed.gov/fulltext/ED612409.pdf (accessed Aug. 08, 2023).

[12]   M. Brown, R. McGreal, and M. Peters, "A Strategic Institutional Response to Micro-Credentials: Key Questions for Educational Leaders," *Journal of Interactive Media in Education*, vol. 2023, no. 1, pp. 1–17, 2023, doi: 10.5334/jime.801.

[13]   K. Ahsan, S. Akbar, B. Kam, and M. D.-A. Abdulrahman, "Implementation of micro-credentials in higher education: A systematic literature review," *Education and Information Technologies*, 2023, doi: 10.1007/s10639-023-11739-z.

[14]   C. Liu, D. Zou, X. Chen, H. Xie, and W. H. Chan, "A bibliometric review on latent topics and trends of the empirical MOOC literature (2008–2019)," *Asia Pacific Education Review*, vol. 22, no. 3, pp. 515–534, 2021, doi: 10.1007/s12564-021-09692-y.

[15]   L. Zhang, R. A. Carter, X. Qian, S. Yang, J. Rujimora, and S. Wen, "Academia's responses to crisis: A bibliometric analysis of literature on online learning in higher education during COVID-19," *British Journal of Educational Technology*, vol. 53, no. 3, pp. 620–646, 2022, doi: 10.1111/bjet.13191.

[16]   N. Donthu, S. Kumar, D. Mukherjee, N. Pandey, and W. M. Lim, "How to conduct a bibliometric analysis: An overview and guidelines," *Journal of Business Research*, vol. 133, no. May, pp. 285–296, 2021, doi: 10.1016/j.jbusres.2021.04.070.

[17]   R. Todeschini and A. Baccini, *Handbook of Bibliometric Indicators: Quantitative Tools for Studying and Evaluating Research*, vol. 128, no. 40. John Wiley & Sons., 2016.

[18]   J. Baas, M. Schotten, A. Plume, G. Côté, and R. Karimi, "Scopus as a curated, high-quality bibliometric data source for academic research in quantitative science studies," *Quantitative Science Studies*, vol. 1, no. 1, pp. 377–386, 2020, doi: 10.1162/qss_a_00019.

[19]   R. Pranckutė, "Web of science (Wos) and scopus: The titans of bibliographic information in today's academic world," *Publications*, vol. 9, no. 12, pp. 1–59, 2021, doi: 10.3390/publications9010012.

[20]   J. T. McAllister, L. Lennertz, and Z. A. Mojica, "Mapping A Discipline: A Guide to Using VOSviewer for Bibliometric and Visual Analysis," *Science and Technology Libraries*, vol. 41, no. 3, pp. 319–348, 2022, doi: 10.1080/0194262X.2021.1991547.

[21]   N. J. van Eck and L. Waltman, "Software survey: VOSviewer, a computer program for bibliometric mapping," *Scientometrics*, vol. 84, no. 2, pp. 523–538, 2010, doi: 10.1007/s11192-009-0146-3.

[22]   B. Fahimnia, J. Sarkis, and H. Davarzani, "Green supply chain management: A review and bibliometric analysis," *International Journal of Production Economics*, vol. 162, pp. 101–114, 2015, doi: 10.1016/j.ijpe.2015.01.003.

[23]   I. Setyaningsih, N. Indarti, and J. Ferry, "Bibliometric analysis of the term green manufacturing," *International Journal of Management Concepts and Philosophy*, vol. 11, no. 3, pp. 315–339, 2018.

[24]   P. N. A. Masitoh, S. Latifah, A. Saregar, A. Aziz, Suharto, and W. Jamaluddin, "Bibliometric analysis of physics problem solving," in *IOP Conference Series: Earth and Environmental Science*, 2021, pp. 1–9. doi: 10.1088/1742-6596/1796/1/012009.

[25]   M. Fuad, E. Suyanto, Sumarno, U. A. Muhammad, and Suparman, "A Bibliometric Analysis of Technology-Based Foreign Language Learning during the COVID-19 Pandemic: Direction for Indonesia Language Learning," *Angewandte Chemie International Edition, 6(11), 951–952., 951–952.*, vol. 12, no. 10, pp. 983–995, 2022.

[26]   K. Ma and B. Yang, "A simple scheme for bibliography acquisition using DOI content negotiation proxy," *Electronic Library*, vol. 32, no. 6, pp. 806–824, 2014, doi: 10.1108/EL-09-2012-0121.

[27]   P. Miteshkumar, "Time Series Analysis of Research Output of Social Sciences in India During 2005–2014," *A Journal of Library and Information Science*, vol. 55, no. 4, pp. 605–615, 2017.

[28]   M. A. Adeoye, O. P. Akinnubi, and G. Rullyana, "A Bibliometric Analysis on Research Trends of Digital Leadership in Education," *Pedagogia Jurnal Ilmu Pendidikan*, vol. 21, no. 2, pp. 137–152, 2023, doi: 10.17509/pdgia.v21i2.59082.

[29]   S. Deng and S. Xia, "Mapping the interdisciplinarity in information behavior research: a quantitative study using diversity measure and co-occurrence analysis," *Scientometrics*, vol. 124, no. 1, pp. 489–513, 2020, doi: 10.1007/s11192-020-03465-x.

[30]   C. L. Lai, "Trends of mobile learning: A review of the top 100 highly cited papers," *British Journal of Educational Technology*, vol. 51, no. 3, pp. 721–742, 2020, doi: 10.1111/bjet.12884.

[31]   P. Sjögårde and F. Didegah, "The association between topic growth and citation impact of research publications," *Scientometrics*, vol. 127, no. 4, pp. 1903–1921, 2022, doi: 10.1007/s11192-022-04293-x.

[32]   B. Hjørland, "Facet analysis: The logical approach to knowledge organization," *Information Processing and Management*, vol. 49, no. 2, pp. 545–557, 2013, doi: 10.1016/j.ipm.2012.10.001.

[33]   J. V. White and C. J. Borgholthaus, "Who's in charge here? A bibliometric analysis of upper echelons research," *Journal of Business Research*, vol. 139, pp. 1012–1025, 2022, doi: 10.1016/j.jbusres.2021.10.028.

[34]   S. E. Lee, N. Ju, and K. H. Lee, "Service chatbot: Co-citation and big data analysis toward a review and research agenda," *Technological Forecasting and Social Change*, vol. 194, no. June, p. 122722, 2023, doi: 10.1016/j.techfore.2023.122722.

[35]   D. E. Rossetto, R. C. Bernardes, F. M. Borini, and C. C. Gattaz, "Structure and evolution of innovation research in the last 60 years: review and future trends in the field of business through the citations and co-citations analysis," *Scientometrics*, vol. 115, no. 3, pp. 1329–1363, 2018, doi: 10.1007/s11192-018-2709-7.

[36]   Z. Liu, Y. Yin, W. Liu, and M. Dunford, "Visualizing the intellectual structure and evolution of innovation systems research: a bibliometric analysis," *Scientometrics*, vol. 103, no. 1, pp. 135–158, 2015, doi: 10.1007/s11192-014-1517-y.

[37]   H. A. Al-Jamimi, G. M. BinMakhashen, and L. Bornmann, *Use of bibliometrics for research evaluation in emerging markets economies: a review and discussion of bibliometric indicators*, vol. 127, no. 10. Springer International Publishing, 2022. doi: 10.1007/s11192-022-04490-8.

[38] E. Djeki, J. Dégila, C. Bondiombouy, and M. H. Alhassan, "E-learning bibliometric analysis from 2015 to 2020," *Journal of Computers in Education*, vol. 9, no. 4, pp. 727–754, 2022, doi: 10.1007/s40692-021-00218-4.

[39] L. Zhang, J. Ling, and M. Lin, "Artificial intelligence in renewable energy: A comprehensive bibliometric analysis," *Energy Reports*, vol. 8, pp. 14072–14088, 2022, doi: 10.1016/j.egyr.2022.10.347.

[40] X. Niu and B. M. Hemminger, "A study of factors that affect the information-seeking behavior of academic scientists," *Journal of the American Society for Information Science and Technology*, vol. 63, no. 2, pp. 336–353, 2012, doi: https://doi.org/10.1002/asi.21669.

[41] P. Vilar, P. Juznic, and T. Bartol, "Information behaviour of Slovenian researchers: Investigation of activities, preferences and characteristics," *Information Research: An International Electronic Journal*, vol. 20, no. 2, pp. 1–12, 2015.

[42] M. Thelwall *et al.*, "Why are coauthored academic articles more cited: Higher quality or larger audience?," *Journal of the Association for Information Science and Technology*, vol. 74, no. 7, pp. 791–810, 2023, doi: 10.1002/asi.24755.

[43] M. H. Anderson and R. K. Lemken, "Citation Context Analysis as a Method for Conducting Rigorous and Impactful Literature Reviews," *Organizational Research Methods*, vol. 26, no. 1, pp. 77–106, 2023, doi: 10.1177/1094428120969905.

[44] V. Larivière, N. Desrochers, B. Macaluso, P. Mongeon, A. Paul-Hus, and C. R. Sugimoto, "Contributorship and division of labor in knowledge production," *Social Studies of Science*, vol. 46, no. 3, pp. 417–435, 2016, doi: https://doi.org/10.1177/030631271665004.

[45] H. Shen, J. Xie, J. Li, and Y. Cheng, "The correlation between scientific collaboration and citation count at the paper level: a meta-analysis," *Scientometrics*, vol. 126, no. 4, pp. 3443–3470, 2021, doi: 10.1007/s11192-021-03888-0.

[46] D. K. Mah, "Learning Analytics and Digital Badges: Potential Impact on Student Retention in Higher Education," *Technology, Knowledge and Learning*, vol. 21, no. 3, pp. 285–305, 2016, doi: 10.1007/s10758-016-9286-8.

[47] H. A. Alamri, S. Watson, and W. Watson, "Learning Technology Models that Support Personalization within Blended Learning Environments in Higher Education," *TechTrends*, vol. 65, no. 1. pp. 62–78, 2021. doi: 10.1007/s11528-020-00530-3.

[48] K. L. Carey and J. E. Stefaniak, "An exploration of the utility of digital badging in higher education settings," *Educational Technology Research and Development*, vol. 66, no. 5, pp. 1211–1229, 2018, doi: 10.1007/s11423-018-9602-1.

[49] P. Dyjur and G. Lindstrom, "Perceptions and Uses of Digital Badges for Professional Learning Development in Higher Education," *TechTrends*, vol. 61, no. 4, pp. 386 – 392, 2017, doi: 10.1007/s11528-017-0168-2.

[50] Facey-Shaw, L. Specht, P. M. van Rosmalen, and J. Bartley-Bryan, "Do Badges Affect Intrinsic Motivation in Introductory Programming Students?," *Simulation and Gaming*, vol. 51, no. 1, pp. 33–54, 2020, doi: 10.1177/1046878119884996.

[51] Z. Cheng, S. L. Watson, and T. J. Newby, "Goal Setting and Open Digital Badges in Higher Education," *TechTrends*, vol. 62, no. 2, pp. 190–196, 2018, doi: 10.1007/s11528-018-0249-x.

[52] R. M. Selvaratnam and M. D. Sankey, "An integrative literature review of the implementation of microcredentials in higher education: Implications for practice in Australasia," *Journal of Teaching and Learning for Graduate Employability*, vol. 12, no. 1, pp. 1–17, 2021, doi: 10.21153/JTLGE2021VOL12NO1ART942.

[53] T. J. Newby and Z. Cheng, "Instructional digital badges: effective learning tools," *Educational Technology Research and Development*, vol. 68, no. 3, pp. 1053–1067, 2020, doi: 10.1007/s11423-019-09719-7.

[54] M. Brown, M. N. G. Mhichil, E. Beirne, and C. M. Lochlainn, "The global micro-credential landscape: Charting a new credential ecology for lifelong learning," *Journal of Learning for Development*, vol. 8, no. 2, pp. 228–254, 2021, doi: https://doi. org/10.5334/jime.801.

[55] L. Wheelahan and G. Moodie, "Gig qualifications for the gig economy: micro-credentials and the "hungry mile," *Higher Education*, vol. 83, no. 6, pp. 1279–1295, 2022, doi: 10.1007/s10734-021-00742-3.

[56] I. Goksu, "Bibliometric mapping of mobile learning," *Telemat. Informatics*, vol. 56, 2021, doi: 10.1016/j.tele.2020.101491.

[57] R. Peacock, H. Grevatt, E. Dworak, L. Marsh, and S. Doty, "Developing and evaluating an asynchronous online library microcredential: a case study," *Reference Services Review*, vol. 48, no. 4, pp. 699–713, 2020, doi: 10.1108/RSR-07-2020-0048.

[58] A. Januszewski and M. Molenda, *Definition and Terminology Committee of the Association for Educational Communications and Technology*. New York: Routledge, 2008.

[59] G. David, C. Kathryn, and I. Leah, "Learning Journeys in Higher Education: Designing Digital Pathways Badges for Learning, Motivation and Assessmen," in *Foundation of Digital Badges and Micro-Credentials: Demonstrating and Recognizing Knowledge and Competencies*, 2016, pp. 115–138. doi: 10.1007/978-3-319-15425-1.

[60] T. Hunt, R. Carter, L. Zhang, and S. Yang, "Micro-credentials: the potential of personalized professional development," *Development and Learning in Organization*, vol. 34, no. 2, pp. 33–35, 2020, doi: https://doi.org/10.1108/DLO-09-2019-0215.

[61] T. Hunt, R. Carter, S. Yang, L. Zhang, and M. Williams, "Navigating the Use of Microcredentials," *Journal of Special Education Technology*, vol. 37, no. 1, pp. 3–10, 2022, doi: 10.1177/0162643420933568.

[62] S. Varadarajan, J. H. L. Koh, and B. K. Daniel, "Correction: A systematic review of the opportunities and challenges of micro-credentials for multiple stakeholders: learners, employers, higher education institutions and government (International Journal of Educational Technology in Higher Education, (20," *International Journal of Educational Technology in Higher Education*, vol. 20, no. 1, pp. 1–24, 2023, doi: 10.1186/s41239-023-00393-7.

[63] S. Kato, V. Galán-Muros, and T. Weko, "The emergence of alternative credentials," *OECD Education Working Papers*, 2020. doi: 10.1787/b741f39e-en.

[64] R. E. West, T. Newby, Z. Cheng, A. Erickson, and K. Clements, "Acknowledging All Learning: Alternative, Micro, and Open Credentials," in *Handbook of Research in Educational Communications and Technology: Learning Design: Fifth Edition*, 2020, pp. 593–613. doi: 10.1007/978-3-030-36119-8_27.

BIOGRAPHIES OF AUTHORS

Riche Cynthia Johan 🆔 🇬 SC ◐ is a lecturer in the Department of Curriculum and Educational Technology, Library and Information Science Study Program. Currently she is the Head of the Indonesian Education University Library (2019-Present). She dedicates herself to taking part in overseeing the development of the competency of library staff by becoming a BNSP Competency Assessor in several competency test schemes. She is also active on the board of the Association of Educational Technology Study Programs (APSTPI). She can be contacted at email: riche@upi.edu.

Gema Rullyana ⓘ 🔗 SC ◗ is a lecturer in the Department of Curriculum and Educational Technology, Library and Information Science Study Program. He received a Master's degree in information and library science from Padjadjaran University, Indonesia, and a Bachelor's degree in Educational Technology from the Indonesian Education University, Bandung, Indonesia, and is currently pursuing a doctoral program at the Educational Technology study program, Jakarta State University, Indonesia. He has written several papers on educational technology, learning resources, online learning, micro-learning, and ICT in libraries. He can be contacted at email: gemarullyana@upi.edu.

Rudi Susilana ⓘ 🔗 SC ◗ is a professor in the Department of Curriculum and Educational Technology, Curriculum Development Study Program. He received a Doctorate in Curriculum Development from the Indonesian University of Education, a master's in Social Sciences from Airlangga University, Indonesia, and a bachelor's in Curriculum and Educational Technology from IKIP Bandung, Indonesia. He is listed as a lecturer in the postgraduate curriculum development program at the Faculty of Education, Indonesian Education University. He has written several papers and books on curriculum and learning, curriculum development, micro-curriculum, learning media, and micro-learning. He can be contacted at email: rudi_susilana@upi.edu.

Mario Emilzoli ⓘ 🔗 SC ◗ is a lecturer at the Educational Technology Study Program, Universitas Pendidikan Indonesia. He has a Bachelor's degree in Educational Technology, a Master's in Curriculum Development and a Doctorate in Curriculum Development. Currently, he is assigned as Secretary of the Educational Technology Study Program, Faculty of Education, University of Education (2023-2027). He has a focus of expertise in the areas of micro curriculum, digital-based learning design, and training curriculum design. He can be contacted at email: emilzoli@upi.edu.