The Implementation of Micro-Credentials in Formal and Informal Learning: A Systematic Literature Review

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Abstract—**When educational institutions across the globe closed because of the COVID-19 crisis, they rapidly had recourse to emergency remote teaching, online learning, and self-paced training. Such an unprecedented situation accelerated the movement and uptake on courses from online platforms such as Coursera, Udemy, etc. As such, modular learning was seen as a way for learners and professionals to keep on upskilling and reskilling themselves both in academic and professional areas. The recognition of the knowledge acquired, and competencies demonstrated by learners, via a new credentialing system, termed as micro-credentials, is seen as a novel, but ambitious approach that is being portrayed as a highly probable future of education systems. However, several research studies have been conducted in this area with little breakthrough or widescale implementation that has led to substantive changes in existing educational systems and models. This paper presents a systematic literature analysis to understand how micro-credentials concept has so far been implemented in educational contexts, its potential to be recognized as transferable credits in formal higher education and the technologies being implemented to store, stack and manage micro-credentials. The data collection process consisted of selecting articles published in the past ten years. The results show that although there is a growing interest in this research area, there is significant divide between applications and recognition of micro-credentials. Hence, this paper reports a summary of prior research conducted and help in identifying the gaps in research studies with respect to the implementation of micro-credential in formal and informal learning.**

Keywords—**micro-credentials, digital badges, emergency remote teaching, e-learning, informal learning, formal learning, learning recognition, stacked modules**

I. INTRODUCTION

Digital technologies influence the way we engage in learning as well as how we access learning opportunities from professional development and skill-based short courses. As they become an important element in the education system, an exponential rise in accessing courses from Massive Open Online Courses (MOOCs) platforms such as Coursera, EdX, FutureLearn and Swayam was observed [1, 2]. Such platforms, in many cases, provide pre-designed and sometimes instructor-led or even self-directed learning courses that focus on developing learners' specific skills, competencies, and knowledge in specific area. While this can be seen as an improvement in the effectiveness of education and innovation in learning, there is also the issue of recognizing, accrediting, and certifying that learning outcomes have been achieved and assessed against certain quality-assured standards [3]. Micro-credentials are certified attestations that can be recognized as proof of learning achievement of short learning interventions whose focus is on validating competency-based skills [4–6].

II. STATE OF THE ART

There are different definitions and interpretations for micro-credentials that have been formulated by policy makers, stakeholders, and scholars [7–9]. But according to UNESCO report [10], there was no universally recognized definition that experts have "agreed to agree on". It has also been observed from surveys conducted that micro-credentials are not properly understood by employers [11, 12]. In simple terms, it can be inferred that they are certified documents (credentials) that attest and validate learners' knowledge, skills, and competencies achieved in a focused area and which can be used to enhance their employability prospects. Rudy and Ponte [13] defined micro-credentials as short learning courses that are flexible and available online and which can be validated and assessed through a digital badge certification that can be attached to an academic transcript. Arguably, Willis, Strunk, and Hardtner [14] explained that micro-credentials can be earned and accepted as the value of formal education, in the workplace, unlike formal credits which are attached to approved curricular designs. Other researchers also relate to micro-credentials as a credentialling system, that adheres to competency-based professional learning, and employs digital badges to acknowledge learners' abilities, successes, and endorse their accomplishments [15]. Similarly, in its description, the New Zealand Qualifications Authority [16] explained that micro-credentials emphasized on the opportunities of skills and competencies development, which are not

currently accommodated by the higher education system, but which can be used as strong supporting evidence for the labour market demands. As such, they can be used as indicators of competency in the workplace and industry.

Micro-credentials are receiving growing interests from higher education institutions. For example, Deakin University in Australia, University of California-Irvine, Western Governors University, Massachusetts Institute of Technology (MIT), State University of New York (SUNY), University of Albany in the USA, Athabasca University, Ontario Tech University in Canada, and Tecnologico de Monterrey in Mexico including university consortia like the OERu in New Zealand, the Micro-credentials Marketplace in Australia, the European MOOC Consortium (EMC), as well as eCampus Ontario and BCcampus in Canada have all entered into the micro-credential field [17]. The Athabasca University emphasize on the potential affordance of micro-credentials that are not necessarily formalized, but that can provide learners with a 'quick impact' training for just-in-time job prospects [17]. This is also because micro-credentials are a discourse of employability skills in higher education which closely aligns with the industry requirements. However, there is still impediment in some universities to fully recognized micro-credentials earned, by questioning the academic rigor of the learning achievement and the volume of learning. Therefore, as Kumar *et al.* [18] explained that it is important to strategize micro-credentials by promoting their adaptation in higher education institutions, through coherent policies and frameworks.

Moreover, a review of the Australian Qualifications Framework (AQF) stressed the importance for the framework and for the higher education sector to be more responsive to the demands of the labour market [19]. To help provide some form of stimulus, micro-credentials were seen as an appropriate measure and an enabler to help address the skills shortages [20]. Coupled with the guidelines of the AQF review, there was a recommendation for the framework to recognize and formalize micro-credentials [21]. Such initiative was also supported by the Australian Federal Government which was looking into the possibility to invest in a national platform for micro-credentials to give students opportunities to learn specialized skills within targeted fields [22]. Micro-credentials are also gaining increased momentum in the professional context, especially from the employers' perspectives. Employers are more interested in recruiting graduates who have mastered employability skills as well as acquired professional knowledge [23]. They have a preferred demand for people with 'skills' rather than 'degrees' [24]. With micro-credentials, the students are given the opportunity to develop specific industry-recognized skills throughout a program, which when they are combined with the educational transcript, fulfill the required profile of the students for the workplace [25]. However, Krauss [26] mentioned in her report about the quality controls of micro-credentials especially in terms of their issuance from non-formal education providers. Arguably, Ralston [27] explains how micro-

credentials have become the preferred option for the industry to upskill and reskill their working professionals rather than enrolling in university degree programs. And employers recognize the value of micro-credentials. Hence, it is important to promote the partnership between higher education providers and the industry to address the gap surrounding competency-based micro-credentials.

An interesting concept that micro-credentials provide is stackability, similar to the concept of credit accumulation, that is, its ability to aggregate and stack modular learning sequences that have been accumulated over time, towards achieving larger unit of competence or qualification or macro-credentials [28, 29]. In 2020, the UK Government committed to create a flexible funding scheme to support the stackability and portability of micro-credentials. The scheme was to help youngsters to *break their study into segments and that can be transferrable between universities*, rather than having three or four years of study at one go [17]. On the other hand, Chakroun and Keevy [30] postulated that stacking micro-credentials will not lead to coherent qualifications. Arguably, the European Commission report (European Commission, Directorate General for Education *et al.*) [31] mentioned a blockchain-based cloud service that was developed by the MicroHE Consortium, to allow institutions to issue micro-credentials. The system was also designed to allow students to achieve micro-credentials that were stacked and accumulated over time, even from different institutions, using the European Credit Transfer Accumulation System (ECTS). Hence, the system recognizes learning achieved and facilitates the smooth recognition of micro-credentials, given that ECTS is a recognized and measurable mechanism for learning. Therefore, the portability and transferability of micro-credentials can potentially be established through ECTS, while the credentials achieved can be stored in a tamper-proof format, within a secure and trustworthy infrastructure [32].

As can be seen from the above literature, micro-credentials have been studied and debated from different perspectives. However, there is no standard structure that explains the processes of how micro-credentials have been implemented. It is therefore relevant to conduct a literature review on the implementation of micro-credentials to further inform practitioners, policy makers, and researchers wishing to engage in this endeavor. Cooper's [33] approach was deemed suitable for this review, given that it focuses on extensive analysis of literature, which analyses useful characteristics such as focus, goal, perspective, coverage, organization, and audience. This review will help to address fundamental questions that relate to the implementation of micro-credentials. The ultimate goal is to identify potential ways to support micro-credentials and their contribution to shaping the future of the industry and education 4.0. Education 4.0 is the trend that prepares future graduates for their smooth integration in the industry with technologies being aligned to allow new possibilities [34, 35]. Hence, this review will also provide evidence-based directions for the future of education.

III. RESEARCH QUESTION AND METHODS

This study employs a systematic literature review approach in line with Cooper's [33] taxonomy of reviews, to identify key research publications and relevant peer-reviewed studies related to micro-credentials and how effectively they have been or can be implemented in the higher education system and the professional contexts. The aim is also to gather what others have done in this area to address any challenges in its recognition as the micro-credentialing approach is still an emerging initiative in the education ecosystem, but it has the potential to shape the future of education. A systematic literature review was deemed appropriate to achieve the aim of this research. Therefore, the following specific research questions are set for this research:

- **RQ1:** To what extent are micro-credentials being implemented and recognized in higher education and professional development contexts?
- **RQ2:** What are the technologies and systems that have been implemented to store, stack, and manage micro-credentials?

To address the research questions using Cooper's [33] approach, the following steps were adopted:

(1) The selection procedure emphasizes on (i) the state of implementation of micro-credentials in the higher education sector, (ii) a comprehensive review of micro-credential as a type of recognition of learning in higher education and professional contexts, (iii) the stackability of micro-credentials towards a qualification. The selected electronic databases for the literature review were the directory of open access journals, Science Direct, Emerald Insight, Google Scholar, Scopus, IEEE, Taylor & Francis Online.

(2) Only full papers published in English language and peer-reviewed related to the main research questions were eligible for inclusion. The papers were also categorized as Empirical Research, Practice Reports, and Conceptual Papers.

(3) To analyze the resulting articles, key information from each article, including the main findings and discussion were summarized.

(4) As a final step, to analyze and synthesize data, qualitative analysis was carried out to conceptualize the relevance of micro-credentials as a growing domain in academia and professional practice.

IV. INCLUSION/EXCLUSION CRITERIA

The inclusion and exclusion criteria are developed and established to increase the likelihood of collecting the most significant, reliable, and accurate results. As such, in this study, they are defined as follows:

- Inclusion criteria
  (a) Articles written in English language
  (b) Articles published between the year 2012 to the year 2022
  (c) Articles in peer-reviewed journals
  (d) Research studies and articles that fall within the parameters of the aim of the study
  (e) Full research paper available from databases
- Exclusion criteria
  All documents that do not meet the inclusive requirement were discarded, because they do not necessarily respond to the aim of the study and to the research questions.

V. SEARCH STRATEGY

There have been a few keywords that were used as search strategy to search for relevant studies, in the different databases. And, following consultation with established researchers in the field, it was decided to search for the following list of terms, which are for example: 'microcredentials in higher education' OR 'micro-credential in higher education' OR 'micro-credential in professional development' OR 'micro-credential in lifelong learning' OR 'micro-credential implementation' OR 'recognition of micro-credential' OR 'concept of micro-credential in formal and informal learning' OR 'micro-credentialing ecosystem' OR 'micro-credentialing structure' OR 'identity of micro-credential'. All possible terms were paired in the search for micro-credentials from the different databases and the search was conducted for the year 2012 to 2022.

VI. SELECTION PROCESS

Given that the aim of this review was to produce a scientific summary of the evidence in micro-credentials with regard to the research questions, the first comprehensive search from the different databases yielded an initial sample of 9030 articles. Fig. 1 shows the search result per database in terms of the number of articles and percentage of articles retrieved.
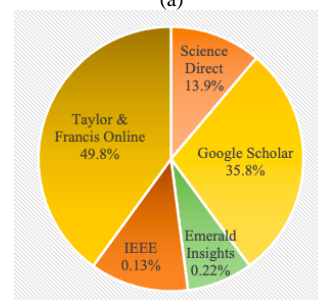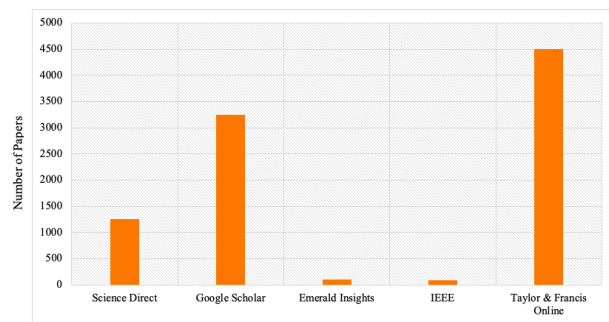

(a)

(b)

Figure 1. The search result per database: (a) Number of articles retrieved per database; (b) Percentage of articles retrieved per database.

326 relevant articles were targeted for analysis of what has been done in the context of this paper. 245 were selected after removing the duplicates. After a first screening of the abstracts and titles, 38 articles were removed based on inclusion criteria (a). After a second screening, 52 articles were excluded given that they do not appear to be specifically relevant to address the research questions set in this paper. There was further exclusion of 117 articles as 18 were posters and abstract only, 65 were of different context and the literature did not focus on micro-credentials, 12 were published before 2012 and in this study, the idea was to look at articles that were published for the past decade and 22 were not peer-reviewed articles. As such, a total number of 38 articles were included for full text review, after validity and reliability analysis. The selection of the articles was also reviewed by colleagues to ensure validity and reliability of the inclusion and exclusion decision.

VII. DATA EXTRACTION AND ANALYSIS

As a result of the study selection process, the final set of articles for analysis is 38, which are relevant publications for this systematic review. Now, the data extraction process will help to address the research questions. To facilitate this process, the following criteria for review were used:
(1) Title of the paper
(2) Author(s)
(3) Year of publication
(4) Country of study
(5) Type of publication

As the purpose of this paper was to explore the extent of the implementation and recognition of micro-credentials in higher education and professional context, as well as the technologies in place to store, stack, and manage them, some key themes emerged from the research questions. These include:
(1) Implementation of micro-credentials in higher education
(2) Recognition of micro-credentials in higher education and professional context
(3) Micro-credential system
(4) Micro-credential stackability, storage and management

The extracted data was then analyzed using the key themes that emerged.

VIII. OBSERVATIONS

This section details an analysis of relevant articles chosen and evaluates and interprets the significance of the findings while addressing the research questions of this study based on the criteria defined and themes that emerged from the research questions. The global micro-credentials landscape is growing and for the past decade, it was noted that much research have been conducted with the view to design and implement micro-credentials in higher education, especially since the COVID-19 crisis. To address this question, it was important to understand the trends that published research on micro-credentials took for the past 10 years and their geographical

distribution. Fig. 2 shows the distribution of articles published on micro-credentials and its implementation and recognition in higher education and in the professional context. There has been an upward trajectory as can be seen from 2013 to 2016, although in 2017, there has been a slight noticeable decrease. This reflects that there has been increased researchers' interests to delve into this area, although the decrease in 2017 can possibly be that some studies are still in progress and not yet published and indexed. And from 2018 to 2020, there has been a constant number of publications. A peak was also seen in 2021, where 10 research articles were published while 2022 shows a slight decrease. There is a possibility that research publications that have been published and indexed in the different databases after August 2022, have not been taken into consideration given that the data gathering process took place earlier.
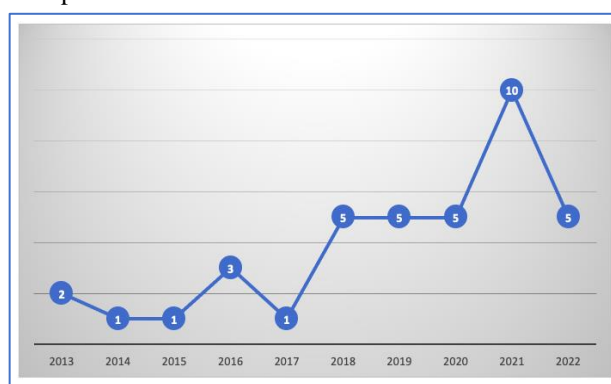

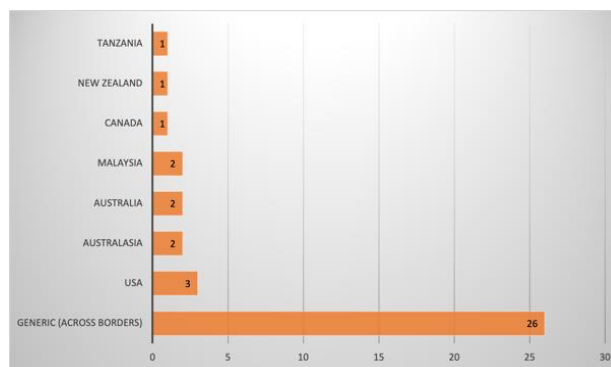
Figure 2. Number of publications per year.

Figure 3. Geographical distribution of published research work.

Moreover, with regard to the geographical distribution of the publications, that come from different countries, Fig. 3, illustrates the number of articles that have been published per country. Publications that have been indexed in the different selected databases in this study, come from Tanzania (n = 1, 2.6%), New Zealand (n = 1, 2.6%), Canada (n = 1, 2.6%), Malaysia (n = 2, 5.3%), Australia (n = 2, 5.3%), Australasia (n = 2, 5.3%), USA (n = 3, 7.9%), and Generic which is across borders (n = 26, 68.4%). These geographical distributions relate to the place the study took place and as such, for the generic category, the studies were carried out in general and not in any specific country. As we can see, for the last decade, there has been a common interest to investigate the opportunities of micro-credentialling around the globe and how it can

enhance the pathway to educational attainment, although, there seems to be less published research work conducted in specific countries.
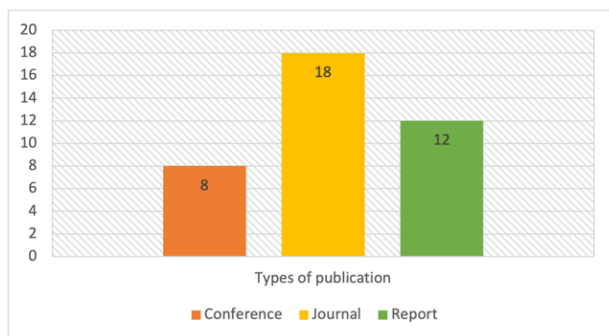

Figure 4. Distribution of articles order by type of publication.

Fig. 4 depicts the distribution of articles ordered by the type of publication. We have three defined categories, which are conference, journal, and report publications. The majority of the articles were published in journal (47.4%) which are peer-reviewed, and give a good visibility in this research area. 8 articles (21%) were published in conference proceedings while 12 reports (31.6%) which are of technical nature but directly related to micro-credentials, were published in colloquiums.

As it has been mentioned earlier, some key themes emerged from the extracted data. Therefore, a classification of the relevant studies with the key themes that will help to address the research questions, has been detailed in Table I, as an extract.

TABLE I. RELEVANT STUDIES WITH EXTRACTED THEMES

Authors	Theme	Research Question
Catalano & Doucet [36]	Open badge infrastructure	RQ2
Halavais [37]	Credibility of micro-credentials and micro-certifications	RQ1
Elliott, Clayton & Iwata [7]	Micro-credentialling ecosystem	RQ2
Lemoine & Richardson [38]	Credit and recognition for eLearning, micro-credentials in higher education	RQ1
Fedock *et al.* [39]	Using micro-credentials for recognition of educational accomplishments	RQ1
Willis, Strunk & Hardtner [14]	Stackability, powers of micro-credentials	RQ2
Bettinger and Soliz [25]	Short credentials	RQ1
Krauss [26]	Micro-credentials and competency-based education in higher education	RQ1
Hölbl *et al.* [40]	Blockchain technology for micro-credentials	RQ2
Lim *et al.* [41]	Implementation of micro-credentials, recognition of learning, micro-credential principles, micro-credentials learning management system, micro-credential ecosystem	RQ1 RQ2
Chakroun & Keevy [30]	Recognition of micro-credentials, stackability of micro-credentials, micro-credentials ecosystem	RQ1 RQ2
Ehlers [42]	Higher education, state of research on micro-credentialling, consequences for higher education	RQ1
Pickard, Shah, and Simone [28]	Types of micro-credentials on the market, academic credit, modularity and stackability	RQ1 RQ2
Rossiter and Tynan [29]	Micro-credentialling ecosystem, issuance model of micro-credentials	RQ1 RQ2
Ghasia, Machumu, and Smet [15]	Implementation of micro-credentials in higher education, creation of micro-credentials ecosystem	RQ1
Ruddy and Ponte [13]	Implementation of micro-credentials in higher education, Micro-credentials and workplace skills, academic integrity micro-credentials	RQ1
Kilsby and Goode [43]	Micro-credentialling system	RQ2
Duklas [44]	Institutional perspectives on micro-credentials, employer perspectives on micro-credentials, portability on micro-credentials, human resources specialist perspectives on micro-credentials	RQ1
Kato, Galán-Muros, and Weko [11]	Micro-credential programmes, platform hosting micro-credentials, micro-credential framework	RQ2
Futures, Andersen, and Larsen [45]	Framework and building blocks, portability, issuing, storage and sharing of micro-credentials, recognition and validation of micro-credentials, credits for micro-credentials, digital platform for micro-credentials	RQ1 RQ2
Selvaratnam and Sankey [46]	Implementation and practice in higher education, micro-credentialling framework, technical infrastructure for micro-credentials	RQ1 RQ2
Martinez-Marroquin, and Male [47]	Recognition, micro-credentials in professional context, embed workplace practice in micro-credentials	RQ1
Wheelahan and Moodie [48]	Implementation of micro-credentials in higher education, alignment with labour market, higher education curriculum, qualification framework, micro-qualification	RQ1
Selvaratnam and Sankey [21]	Implementation of micro-credentials, portability and sustainability of micro-credentials, technical system to support micro-credentials, technology ecosystem, stackable credit, micro-credentials for the professional marketplace, recognition of micro-credentials	RQ1 RQ2

RQ1: To what extent are micro-credentials being implemented and recognized in higher education and professional development contexts?

The relatively high volume of research that has been carried out on micro-credentials in higher education is evident. Selvaratnam and Sankey [21, 46] investigated about the implementation of micro-credentials within the Australasian region. They reported that several institutions have established mature adoption policies for micro-credentialling and have begun to set in place taxonomies to formalize micro-credentials. In the United States, owing to the education and skills gaps and economic inequity among underserved learners, competency-based micro-credentials are seen as one strategy to equip and empower them with high quality credentials for the future [26]. Krauss [26] also mentioned in the Lumina paper, that to achieve the strategy, it is important for state policymakers to earmark specific innovation funds that will serve for the design of competency-based education programs, to support the underserved communities. Establishing scholarships as an opportunity to encourage learners is also an approach to supporting them in their education. However, in the African region, especially in Tanzania, the deployment of micro-credentials in universities could not really take place given that there is a need to improve the necessary infrastructure, establish policies, and invest in human resource development and capacity-building [15].

In other studies, Martinez-Marroquin and Male [47] argue that it is important to broaden access to higher education with micro-credentials, by adapting programs and embedding Work-Based Learning (WBL) practices to equip learners with competencies linked to workplace professionalism. They advocate that by formally embedding WBL skills in the curriculum at tertiary level, can increase the employability prospects of learners. This is in line with the demand of the labour market, as essential employability skills are often not prioritized in traditional higher education curricula [42]. Wheelahan and Moodie [48] also demonstrated that micro-credentials can help higher education to align their curricula with workplace requirements. Therefore, from the employer's perspectives, it was reported that it is important for institutions to align their programs using a mix of competency, field experience and project-based education, with the requirements of the industry, given that micro-credentials represent completion and mastery of skills and competencies [23]. In addition, higher education institutions need to have a strategic implementation plan to ensure that their students clearly understand the value and the purpose of earning micro-credentials so that they can market their competencies and achievements to potential employers [36]. As Pickard, Shah, and Simone [28] explained, the growing trend in MOOCs with modular stand-alone courses is giving rise to micro-credentials and seen as a future direction in higher education.

Chakroun and Keevy [30] authored the UNESCO report about digital credentialing with implication for recognition of learning across borders. They discussed about the emergence of micro-credentials and its implications on recognition of learning internationally. They postulated that it is important for the education and training sectors to move forward and adopt digital transformation, as digital technology brings a reliable dimension for the recognition of skills and qualifications. An interesting element that emerged from their literature is that with digital transformation, skills development policy, which is also aligned with the SDG4: '*to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all*' can be achieved. Such policy development can help to support youths and adults in the quest of recognizing their skills and competencies which can be achieved through micro-credentials. Hence, micro-credentials when coupled with innovations enabled by technology seem to support the recognition of micro learning achievement.

According to Futures, Andersen and Larsen [45], the European approach to recognize micro-credentials issued by formal qualified education bodies, is to apply procedures that are utilized for the recognition of international degrees and learning experiences abroad, while using recognition of prior learning and experiences for those that are issued by non-formal education providers. Similarly, it has been reported in the OECD Higher Education Policy working paper, by Kato, Galán-Muros, and Weko [11] that micro-credentials add value to prior learning, experience, and training. They may also be used exceptionally in areas where they are recognized, as a replacement of some formal post-secondary education programmes, to attract non-traditional learners. But the researchers also mentioned that the cost implication can be high, given that the determining factor to award micro-credentials depends on the validating assessment, which weigh on the issuer or provider. However, as concluded by McGreal and Olcott [17], micro-credentials cannot resolve all the institutional challenges but with sound planning, the strategic integration of micro-credentials can pave its way smoothly. It was also reported that higher education institutions are responding positively to the micro-credential movement and traditional degrees are no longer the sole workforce currency [49]. Seeing the potential of micro-credentials, key leaders found it important to include them in the state education policy, especially as it is attracting the interests of the industry [50].

RQ2: What are the technologies and systems that have been implemented to store, stack, and manage micro-credentials?

To answer this question, a considerable number of relevant studies were retrieved and examined. The research publications were categorized from the derived themes. Most of the studies were conducted in the higher education context.

Ehlers [42] explained that micro-credentials need to form part of a learning ecosystem, that is a technical infrastructure that can store, manage, and organize them, so that everything that is related to higher education (education and certification) can be accessible from a single source. While elaborating on a learning ecosystem, Kilsby and Goode [43] explained the EduBits micro-credentialling system, which is an initiative of New Zealand's Otago Polytechnic. The system was designed

for the development and scalability of micro-credentials. It is a platform that allows learners to earn micro-credentials that can later be shared, transferred, and aggregated towards wider credentials. The European approach towards the storage, exchange, and portability of micro-credentials is to make learners own their credential data instead of the issuing body. This is in line with the General Data Protection Regulation that protects the owner of the data and gives the learner the freedom to decide with whom to share the micro-credential [45]. The European approach is universal and not specific to a particular system, and it uses the regulatory framework that creates the right balance of quality assurance to the implementation of micro-credentials [51]. Moreover, the approach also consists of having an infrastructure to securely store and exchange the data. The advisory note is that the platform should be based on open standards to allow for interoperability of micro-credentials [45].

Rossiter and Tynan [29] explained in their guide to practitioners that micro-credentials cannot function in isolation as it is a component within a larger ecosystem. Therefore, it is essential to work closely with the industry and the relevant stakeholders to ensure a homogenous approach that aligns with the endeavor of the professional and educational institutions. Consequently, it is important for the system architecture and framework to include a credential taxonomy that will demonstrate the 'stacks' and 'clusters' of the micro-credential portfolio. The Common Microcredential Framework (CMF), developed within the European MOOC Consortium, uses the 'Bologna' process to recognize micro-credentials for lifelong learning and professional development in the qualification framework. The framework also allows learners to progressively achieve micro and continued learning that can be stackable to a larger programme [52].

There are different digital platforms that can be used to store and manage micro-credentials. A micro-credentialing ecosystem would give the possibility to institutions to have the infrastructure and the framework to encourage learners in earning collections of micro-credentials that reflect their personal and professional achievements. These can also be shared with potential employers who want to review the competencies achieved of an individual [7]. Chakroun and Keevy [30] mentioned in their report that the key consideration is to have a platform or use a technology that is compatible and interoperable where standard data can be seamlessly stacked, managed, and exchanged through the support of secured protocols and common credentialing language. As such, blockchain technology has been identified as having the capacity of communicating and exchanging digital data with technical standards and it is being used in the context of micro-credentials to secure, share, and verify learning achievements [53, 54]. It is presented as a capable ecosystem for managing micro-credentials [40]. The Credential Transparency Description Language (CTDL) as a technology ecosystem is also used to enable stakeholders to recognize varieties of credentials [21].

IX. DISCUSSION

In this paper, a systematic review was conducted to understand how micro-credentials have been implemented and/or recognized in higher education and professional context. The aim was to look at the literature to further inform practitioners, policy makers, and researchers on of the potential of micro-credentials in formal and informal learning contexts. Accordingly, identifying the current situation of micro-credentials and planning how the flexibility of micro-credentials can shape the future of education and industry may also be helpful to those aspiring stakeholders who want to adopt that field. Micro-credentials are increasingly gaining momentum as an emerging trend, and are likely to continue to grow, be it for the future of education or world of work. Its uptake has probably been accelerated due the COVID-19 pandemic given its possibility to rapidly answer to skills shortages.

The first research question investigated the implementation and recognition of micro-credentials. Education institutions across countries, have been debating about the promises of micro-credentials from learner, employee, and employer perspectives. The idea is to identify the main drivers that could facilitate the adoption, implementation, and recognition of micro-credentials. Therefore, working on a comprehensive micro-credentialing policy to support continued education for lifelong learning and professional development and endorse the achievement may be established. Accordingly, the policy can also describe how the implementation can be done through best practices including quality standard monitoring procedures. This may possibly be achieved through a consensus-building process through a futures workshop with key stakeholders, experts, or a global expert panel. An established policy with clear validation metrics, achieved through a coordinated approach, might help to put forward the recognition, transfer, and portability of micro-credentials. As such, higher education institutions can easily align their curricula with workplace requirements [48]. Accordingly, this review confirms the findings that several institutions have established mature adoption policies for micro-credentialling [21, 46].

The second research question aimed to identify the technologies and systems that have been put in place to store, stack, and manage micro-credentials. The literature supports the view that having a trusted registry that can store micro-credentials that have captured formal, non-formal, and informal learning achievements, can also serve as a link to exchange them on-demand with the industry. The platform should be based on open standards to allow for interoperability of micro-credentials and ensure their integrity [45]. What stands out from the published literature is that blockchain can be used as a technology ecosystem to secure, share, and verify learning achievements [53, 54]. It can store stackable credentials that are verifiable and authenticated by the owner of those credentials. Hence, blockchain as a dynamic technology can be used for its intrinsic trustworthiness properties.

X. CONCLUSION

Conducting a systematic literature review on micro-credentials in higher education and professional contexts has highlighted the importance of these credentials as a means of gaining specific skills and knowledge in a shorter time frame than traditional degree programs. The review has revealed that micro-credentials are being used in a range of contexts, including higher education, professional development, and workforce training, and that they have the potential to increase access to education and training for a wide range of learners. Additionally, the review has identified several key factors that impact the effectiveness of micro-credentials, including the quality of the credential issuer, the recognition and acceptance of the credential by employers and other stakeholders. Furthermore, the review has also provided valuable insights into the current state of micro-credentials in higher education and professional contexts and has identified areas for future research and development. It also acknowledges the numerous potential benefits of micro-credentials, while also highlighting some challenges that must not be ignored. Certainly, ongoing researches are needed for better opportunity of micro-credentials in the learner and earner journey. It is clear that micro-credentials have the potential to play a significant role in the future of education and training, and it is important that we continue to explore their effectiveness and impact. Hence, the insights gained from this review can help to establish a balanced understanding of micro-credentials in shaping future work and research activity. Future research in this area could possibly focus on addressing factors to ensure that micro-credentials are effective in preparing learners for the workforce and supporting lifelong learning.

CONFLICT OF INTEREST

The author declares no conflict of interest/competing interests.

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