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THE INTERNATIONAL CASE FOR MICRO-CREDENTIALS FOR LIFE-WIDE AND LIFE-LONG LEARNING: A SYSTEMATIC LITERATURE REVIEW

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ABSTRACT

Aim/Purpose	Systematic literature reviews seek to locate all studies that contain material of relevance to a research question and to synthesize the relevant outcomes of those studies. The primary aim of this paper was to synthesize both research and practice reports on micro-credentials (MCRs).
Background	There has been an increase in reports and research on the plausibility of MCRs to support dynamic human skills development for an increasingly impatient and rapidly changing digital world. The integration of fast-paced emerging technologies and digitalization necessitate alternative learning paradigms. MCRs offer time, financial, and space flexibility and can be stacked into a larger qualification, thereby allowing for a broader range of transdisciplinary competencies within a qualification. However, MCRs often lack the academic rigor required for accreditation within existing disciplines.
Methodology	The study followed the PRISMA framework (Preferred Reporting Items for Systematic Reviews and Meta Analyses), which offers a rigorous method to enhance reporting quality. The study used both academic research and practice reports.
Contribution	The paper makes a theoretical contribution to the discourse about the need for innovation within existing educational paradigms for continued relevance in a changing world. It also contributes to the debate on the role of MCRs in bridging the gap between practice and academia despite the growing difference

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	between their interests, and the role that MCRs play in the social-economic plans of countries.
Findings	The key findings are that investments in MCRs are mainly in the Science, Technology, Engineering and Mathematics (STEM) and Education sectors, and have taken place mainly in high-income countries and regions – contexts that particularly value practice-accredited MCRs. Low-income countries, by contrast, remain traditional and insist on MCRs that are formally accredited by a recognized academic institution. This contributes to a widening skills gap between low- and high-income countries or regions, which results in greater global disparities. There is also a growing divide between academia and practice concerning their interest in MCRs (a reflection of the rigor versus relevance debate), which partially explains why many global and larger organizations have gone on to create their own learning institutions.
Recommendations for Practitioners	We recommend that educational mechanisms consider the critical importance of MCRs as part of innovative efforts for life-wide (different sectors) and life-long (same sector) learning, especially in low-income countries. MCRs provide dynamic mechanisms to fill skills gaps in an increasing ruthless international battle for talent.
Recommendations for Researchers	We recommend focused research into skills and career pathways using MCRs while at the same time remaining responsive to transdisciplinary efforts and sensitive to global and local changes within any sector.
Impact on Society	Work and society have transformed over time, and more so in the new digital age, yet academia has been slow in adapting to the changes, forcing organizations to create their own learning institutions or to use MCRs to fill the skills gap. The purpose of education goes beyond preparing individuals for work, extending further to creating an environment where individuals and governments seek their own social and economic outcomes. MCRs provide a flexible means for co-creation between individuals, education, organizations, and government that could stem global rising unemployment, social exclusion, and redundancy.
Future Research	Future research should focus on the co-creation of MCRs between practitioners and academia.
Keywords	micro-credentials, digital badges, online learning, credentials, education 4.0, COVID-19

INTRODUCTION

The rise of intelligent systems, known as the 4th Industrial Revolution (4IR), and sometimes referred to as Industry 4.0 and Smart Manufacturing, and the resulting redundancies in many industries have again provoked questions about the role of education in a changing world (Bartz & Kritsonis, 2019). The 4IR requires new skills in digital technologies, such as artificial intelligence, machine learning, blockchain, and the internet of things, as well as a culture of life-long learning that was previously not particularly catered for in most formal curricula (Akman & Mishra, 2017; Resei et al., 2019). There is therefore a growing interest in considering the suitability of the current curricula, often strait-jacketed by existing bureaucracy, to meet the changing needs of employers in terms of new skills, competencies, and innovation in a changed 4IR world (Chakroun, & Keevy, 2018; LaMagna, 2017). Those with the required skills which can be applied anywhere and anytime, regardless of geographic region and time zone are few, and in very high demand.

The global COVID-19 pandemic has also rapidly changed professional and personal circumstances, forcing the introduction of a more digital and flexible lifestyle (Karakose, Yirci, & Papadakis, 2021).

These changes present a unique opportunity to revisit the education system and to prepare an already impatient society for more rapid change. One of the leading suggestions has been to consider micro-credentials (MCRs) (Fong et al., 2016; Rubleske & Cata, 2017).

MCRs are credentialing educational systems that follow competency-based professional learning pathways that are particularly easy to access and open for collaboration (Coyne et al., 2019; Fong et al., 2016; Song, 2018). MCRs are often short, interactive, available online, and sector- or practice-focused and can be completed in the individual's own time (Bowen & Thomas, 2014; Crow & Pipkin, 2017; Kazin & Clerkin, 2018; Ruddy & Ponte, 2019; Willis et al., 2016). MCRs also compensate for the rapidly growing demand for skills and competency development not covered by the formal education curricula (Ruddy & Ponte, 2019) and reach a larger audience (Rossiter & Tynan, 2019). In terms of skills pathway integration, an appealing feature of MCRs is their stackability (Casilli & Hickey, 2016) into either a wider range of competencies or into a larger MCR (O'Brien, 2019). For example, EduBits can be stacked into a fully recognized qualification through the recognition of prior learning (RPL) (Kilsby & Goode, 2019).

MCRs have been defined and labelled in different ways (Fong et al., 2016; Resei et al., 2019). For example, in the United States, they are described as learning activities consisting of "more than a single course but less than a full degree" (Kato et al., 2020). In the European Higher Education Area (EHEA), an MCR is a "sub-unit of a credential or credentials that confer a minimum of 5 European Credit Transfer and Accumulation System (ECTS) (credits) and could be part of a portfolio" (MicroHE Consortium, 2019). In New Zealand, MCRs range from 5 to 40 credits (New Zealand Qualifications Authority, 2020), while in England, the higher education credit framework assigns credit to each qualification based on the expected effort (notionally 10 hours per credit point). The English framework is aligned to the ECTS (Oliver, 2019). Others go so far as to refer to MCRs as digital badges (Oliver, 2019), although MCRs and digital badges are not in fact the same thing (Copenhaver & Pritchard, 2017; Lemoine & Richardson, 2015); digital badges are the means of communicating the attainment of learning and can be easily shared with a larger audience on any digital or social media platform (Fishman et al., 2018; Kazin & Clerkin, 2018). Digital badges are, therefore, a subset of MCRs and represent the mechanisms for communicating the attainment of a specific learning outcome (Fishman et al., 2018). This paper focuses on MCRs within the construct of the 4IR (Industry 4.0), and more recently, COVID-19.

MCRs have the following general features:

- **Self-directed:** Individuals can undertake and complete the MCR at their own pace (Acree, 2016; Coyne et al., 2019).
- **Job-embedded:** Each MCR is directly tied to work or experiential learning (Oliver, 2019).
- **Competency-based**: MCRs must assess the ability to apply a specific skill in the workplace (Crow & Pipkin, 2017; Elliott et al., 2014; Kato et al., 2020).
- **Research-based:** MCRs are designed to help bridge skill gaps that have been thoroughly researched (Coyne et al., 2019).
- **Shareable:** MCRs can be shared across many platforms (Coyne et al., 2019).
- **Accredited and recognized:** Accreditation relates to formal recognition in the education sector, such as a degree, or by practice, such as Microsoft, Cisco, IBM, and Google. Recognition relates to the extent to which an educational standard is endorsed through some benchmark, such as the Shanghai Ranking or professional society, either academic or from practice, e.g., project management, accounting, and others (Oliver, 2019; Resei et al., 2019).
- **Delivery and assessment mode (online/offline):** The content and assessments can be downloaded to a device and consumed synchronously online or at a later convenient time. In some instances, MCRs are also delivered/assessed face-to-face (offline) (Coyne et al., 2019; Kato et al.,

2020). There is a growing movement towards coaching as a means of ongoing support in MCRs (Crow & Pipkin, 2017).

- **Duration:** The duration of MCRs differs from no more than a few hours to a number of weeks (Kato et al., 2020; Law, 2015).
- **Skills pathway integration:** MCRs can, in some instances, be stacked as part of a larger subject of focus, or accumulated into a larger recognized credential (Oliver, 2019).
- **Economic sector:** MCRs can relate to the five economic sectors: primary (extraction of raw materials, e.g., mining, agriculture), secondary/manufacturing (producing finished products, e.g., construction, electricity), tertiary/service (intangible goods and services to consumers, e.g., tourism, banking), quaternary (knowledge economy, e.g., education, research) and quinary (government, policy) (Farrow, 2019).

As seen above, MCRs have been pursued differently across practice and research and, as a result, are difficult to focus on as a field of interest. For instance, there is no standard structure as to how endorsing agencies recognize MCRs for personal development credit (Hunt et al., 2019). The purpose of this paper was, therefore, to synthesize both research and practice reports on MCRs and to further identify the opportunities, gaps, and areas for further research and development. For the purposes of this paper, the systematic literature review method was adopted.

The remainder of the paper is structured as follows: the next section presents the methodology used, which is then followed by a discussion of the results using a classification framework. The final section presents the conclusions, implications, limitations, and areas for further research.

METHODOLOGY

Systematic literature reviews seek to locate all studies that contain material of relevance to a research question and to synthesize the relevant outcomes of those studies. For this paper, the specific research question was: "*What is the current status of academic research and practice reports on micro-credentials?*"

PROTOCOL

The study followed the PRISMA framework (Preferred Reporting Items for Systematic Reviews and Meta-Analyses), which offers a rigorous method to enhance reporting quality, maintain transparency, reduce bias (Knobloch et al., 2011), and improve the documentation of the review protocol (Shamseer et al., 2015).

ELIGIBILITY CRITERIA

The eligibility criteria were set as research studies and practice reports published in the 10 years from 2011 to 2020. There were no restrictions on the type of setting. Only articles published in the English language were eligible for inclusion.

INFORMATION SOURCES AND SEARCH

MCRs represent a multidisciplinary topic, and therefore the following multidisciplinary electronic academic databases were accessed to retrieve peer-reviewed research articles on MCRs: IEEE Xplore digital library, Scopus, Science Direct, Google Scholar, and ACM Digital Library. The practice reports were sought through Google, reputable organizations, and peer recommendations. The specific search terms that were used in each of the databases were: "micro credential*", "micro-credential*", "digital credential*", "digital badg*", "credential*", "beta credential*", "beta-credential*".

STUDY SELECTION

Table 1 sets out the inclusion, exclusion, and quality criteria of the systematic review on MCRs.

Table 1: Inclusion, exclusion, and quality criteria of the systematic review on micro-credentials

Inclusion criteria	Exclusion criteria	Quality criteria
Articles published between 2011 and 2020	Published before 2011	Reputable sources such as accredited publications and/or international organizations (to avoid predatory outlets)
Only classical and highly recommended cherry-picked articles published before 2010	Other articles published before 2010	
Written in English	Not written in English	
Double-blind peer-reviewed	Literature did not focus on MCRs	
Recommended grey area literature (non-peer-reviewed)	Discusses digital badges but not MCRs	
Reports from reputable sources (to avoid predatory outlets)		

Search String

The study used the Boolean operator 'OR' in the search string according to the database: "micro credential*" OR "micro-credential*" OR "digital credential*" OR "digital badg*" OR "credential*" OR "beta credential*" OR "beta-credential*". The search was conducted between June 2020 and July 2020.

Study Selection

Table 2 sets out the process used to select the final set of studies. The initial search represents the number of articles returned when the search was performed. The first order represents the first screening based on the keywords, the title, and the abstract. In the second-order search, duplicates were removed. The third-order search eliminated papers using the eligibility criteria recorded in Table 1.

Table 2: Study and report selection process

Electronic database	Initial search	1st-order selection (records identified through initial search)	2nd-order selection (duplicates removed/records screened)	3rd-order selection (used quality criteria)
Scopus	9186	151	366	140
IEEE Xplore Digital Library	1192	30		
Science Direct	3741	33		
Google Scholar	24500	172		
ACM Digital Library	1243	6		
Google search	239	38		
Peer recommendations			12	6

Data Collection Process

The initial search and first-order selection were done by two researchers using the search terms. Three researchers independently performed the second- and third-order selections against the eligibility criteria. Any disagreements were resolved through dialogue. There was no need for an independent arbitrator to resolve differences. Any differences of opinion were documented for further resolution.

Data Extraction and Analysis

To maintain consistency, the three reviewers extracted data independently from each eligible study allocated to them. Extracted data included demographic information, publication, methodology, year, and country of origin. Extracted values were checked by the co-authors to ensure accuracy.

Evaluation of Data Items – Classification and Coding Framework

The study adopted the classification and coding framework of Amui et al. (2017) to facilitate structured data extraction from the final set of selected documents. This framework uses numbers and letter codes to classify the selected studies, as can be seen in Appendix A.

Findings

A descriptive and correlation analysis was performed to understand the relationships between the different class tabled in Appendices A and B. The statistical correlation analysis was included because the number of papers reviewed exceeded 100 (see Appendix C) and could therefore allow for statistical and inferential insights into the strengths and directions of relationships between the different aspects of MCRs. Each sub-section therefore begins with brief descriptive results and then presents a discussion from the most significant statistical inferences that stood out. Because of space constraints, only highly significant inferences are discussed.

Context – High-Income/Low-Income Countries and Continents

69.18% of the studies were conducted in high-income countries (United Nations Development Programme [UNDP], 2022), 16.44% were from a global context (without any specific reference to a country), and fewer than 5% were from low-income countries. 14.38% of the papers were not explicit with regard to country. 53.42% of the articles were North American based, and 15.75% were European. 16.44% did not reference a specific geographical area. MCR research and practice reports from Africa, South America, Asia, and the Middle East were either few in number or completely absent. This illustrates the differentiated interest in MCRs according to income status and region. Table 3 reveals how high-income countries, particularly those in North America and Asia, have invested in implementing MCRs and especially value those that are practice accredited.

Table 3: Context correlations

	Positive correlation	**Negative correlation**
High-income countries	• Implemented • Practice accreditation • North America • Asia	• Digital badge (for a fee) • Quaternary (knowledge economy)
Low-income countries	• Proposal stage • Africa • Asia • South America	• Academic accreditation • Implemented

	Positive correlation	Negative correlation
Global context	• Quaternary (knowledge economy) • Courses related to a career for which registration is needed with the bodies regulating the practice	• Summative assessments • Research and project-based assessment • Academic recognition • Implemented

Pedagogic Approach

53.42% of the MCRs take a self-directed approach to learning, while 26.03% are institution-directed; 17.81% of papers did not mention the pedagogic approach. Table 4 shows how self-directed learning MCRs are not particularly integrated into fuller qualifications even though they lean towards summative and research/project-based assessments.

Table 4: Pedagogic correlations

	Positive correlation	Negative correlation
Self-directed	• Summative assessments • Research or project-based • Digital badge (free) • Academic recognition • Academic research	• Skills pathway integration to larger qualification • Digital badge (for a fee)
Institution-directed	• PDF certificates	• Academic research

Practice and Academic Integration

71.92% of the studies reported on competence-based MCRs, 41.10% concentrated on job embeddedness as part of career pathways, 29.45% of the articles reported a link between skills pathways and the integration thereof in degree qualifications, and 13.01% of the articles did not report any integration between academia and practice. Table 5 shows that MCRs focus primarily on practical and technical competences for jobs and for the trades and do not often concern themselves with the wider implications of the MCRs.

Table 5: Practice and academic integration

	Positive correlation	Negative correlation
Job Embeddedness/Career Pathways	• Experiential (work-integrated learning) • Practice recognition • Practice report (position paper)	• Academic research
Skills pathways integration into large qualification	• PDF certificates • Academic accreditation • Practice report (position paper) • Humanities and social sciences • Courses related to one of the trades • Courses related to a career for which registration is needed with the bodies regulating the practice	• Academic research • Education

Competency and Assessment Approach

35.62% of MCRs used summative assessments, 24.66% used formative assessments (including peer assessment), 15.75% used experiential assessment (work-integrated learning), and 15.07% were research/project-based. 13.01% of papers considered competency and character assessment, while 34.93% were not specific about the approach used for assessment. Table 6 shows the application of competency and assessment approaches in MCRs.

Table 6: Competency and assessment approach

	Positive correlation	**Negative correlation**
Formative or peer assessment	• Digital badge (free) • Academic recognition (recognized by international benchmarks) • Service/tertiary (intangible goods and services to consumers, e.g., tourism, banking, schools, medicine)	• Offline (100%) – teaching and learning delivery mode
Summative	• Self-directed • Digital badge (free) • Academic recognition (recognized by international benchmarks)	• Courses related to one of the trades (plumbing, electrical work, tool, dye making, etc.)
Experiential	• Job embeddedness/career pathways • Academic recognition (recognized by international benchmarks) • Hybrid (online/offline) mode – assessment delivery mode • Ongoing coaching track • Science, Technology, Engineering and Mathematics (STEM) • Service/tertiary (intangible goods and services to consumers, e.g., tourism, banking, schools, medicine)	• Quinary (government, policy)

Communication of Completion

Free digital badges were used as a method for communicating completion in the case of 46.58% of MCRS, while PDF certificates were issued in 23.29% of cases, and a fee was charged for the digital badge in 9.59% of cases. Table 7 shows how the completion of MCRs is communicated in different courses.

Table 7: Communication of completion

	Positive correlation	Negative correlation
PDF certificates	• Science, Technology, Engineering and Mathematics (STEM) • Accounting, Economics and Business Management • Humanities and Social Sciences • Courses related to one of the trades • Courses related to a career for which registration is needed with the bodies regulating the practice	• High-income countries
Digital badges (free)	• Academic recognition • Europe	• Practice recognition • Courses related to a career for which registration is needed with the bodies regulating the practice • North America • Quinary
Digital badges (for a fee)	• Academic accreditation • Asia	• Self-directed

ACCREDITATION AND RECOGNITION

Accreditation promotes the credibility of a standard and adds value to a qualification (Halavais, 2013). 52.05% of the papers focused on academic accreditation, 39.04% focused on practice recognition, 34.93% on academic recognition, and 26.71% on practice accreditation, while 19.86% of papers were not specific. Table 8 shows how accreditation and recognition of MCRs are implemented in different context of education.

Table 8: Accreditation and recognition

	Positive correlation	Negative correlation
Academic accreditation	• Competency and character assessment • Courses related to a career for which registration with professional bodies is needed • Quinary sector • Education • Service/tertiary (intangible goods and services to consumers, e.g., tourism, banking, schools, medicine)	• Low-income countries • Asia • Service/tertiary sector
Practice accreditation	• High-income countries • Experiential (work-integrated learning) • STEM • Humanities and Social Sciences	

	Positive correlation	Negative correlation
Academic recognition	• Self-directed • Experiential (work-integrated learning) • Digital badge (free) • Service/tertiary (intangible goods and services to consumers, e.g., tourism, banking, schools, medicine)	
Practice recognition	• Job embeddedness/career pathways • PDF certificates • STEM • Accounting, Economics and Business Management • Humanities and Social Sciences • Courses related to one of the trades (such as plumbing, electrical work, and tool and dye making) • Courses related to a career for which registration with the bodies regulating the practice (real estate, security, etc.) is needed • Middle East • Primary (extraction of raw materials, e.g., mining, agriculture, mining, forestry, grazing, hunting and gathering, fishing, and quarrying) • Secondary/manufacturing (producing finished products, e.g., construction, electricity) • Quaternary (knowledge economy, e.g., information technology, media, research, and development)	• Digital badge (free)

Teaching and Learning Delivery Mode

48.63% of the papers did not specify the delivery mode. Those that did so emphasized a hybrid delivery model: 23.97% included both online and offline delivery, 20.55% emphasized full online delivery, and 7.53% emphasized full offline delivery. Table 9 shows that most MCRs are highly implemented both online and offline (Hybrid mode) across different categories.

Table 9: Teaching and learning delivery mode

	Positive correlation	Negative correlation
Online (100%)	• Self-directed • Digital badge (free) • Africa • Europe • Middle East	• Competence-based • Research or project-based • Practice recognition • North America

	Positive correlation	Negative correlation
Offline (100%) – include face-to-face	• Exploratory	
Hybrid (online/offline) mode	• Self-directed • Experiential (work-integrated learning) • Research or project-based • PDF certificates • Practice accreditation • Academic recognition • Ongoing coaching track • Implemented • Service/tertiary (intangible goods and services to consumers, e.g., tourism, banking, schools, medicine)	• Quaternary (knowledge economy, e.g., information technology, media, research and development) • Quinary (government, policy)

Assessment Delivery Mode

Assessment is the means through which learning is proven (see Table 10). 45.21% of the papers were not specific with regard to the mechanism of assessment, while 17.81% of the MCRs assessed online and 10.96% assessed through coaching.

Table 10: Assessment delivery mode

	Positive correlation	Negative correlation
Online (100%)	• Self-directed • Digital badge (free) • Proposal stage • Design science • Academic research • Africa • Europe • Middle East	• North America
Offline (100%) – include face-to-face	• PDF certificates • Secondary/manufacturing (producing finished products, e.g., construction, electricity)	
Hybrid (online/offline) mode	• Experiential (work-integrated learning) • Competency and character assessment • Academic recognition (recognized by international benchmarks) • Implemented	

	Positive correlation	Negative correlation
Ongoing coaching track	• Experiential (work-integrated learning) • Research or project-based • Digital badge (free) • Explanatory • Academic research • Service/tertiary (intangible goods and services to consumers, e.g., tourism, banking, schools, medicine)	

Type of Research/Policy/Report

72.60% of the papers were academic research focused, and mainly from high-income countries, while a very small percentage of the articles held a global view. Of the articles, 16.44% related to practice, and 9.59% were policy related. Table 11 shows that academia is investigating the accreditation and recognition of MCRs while practitioners are interested in skills pathways.

Table 11: Type of research

	Positive correlation	Negative correlation
Academic research	• Research or project-based assessment • Accreditation and recognition • Implemented • Service/tertiary	• Job embeddedness • Skills pathways • Quinary
Practice report (position paper)	• Institution-directed • Skills pathways • Proposal stage • Australia • New Zealand	• Education • Service/tertiary

Skills Sector

There are two major categories of MCRs, namely STEM (26.3%) and Education (35.62%). This distribution reveals a gap between the development of 21st century skills and related competencies for specific sectors (see Table 12).

Table 12: Skills sector

	Positive correlation	Negative correlation
Science, Technology, Engineering and Mathematics (STEM)	• Self-directed • Short duration (5 to 40 hours) • Secondary/manufacturing	
Accounting, Economics and Business Management	• Secondary/manufacturing	• Self-directed
Humanities and Social Sciences	• Skills pathways • Long duration (more than 40 hours)	
Education	• Primary (economic sector) • Services/tertiary (economic sector) • Quinary (economic sector)	• Short duration (5 to 40 hours)
Arts	• Self-directed • Quinary (economic sector)	
Courses related to one of the trades (such as plumbing, electrical work, and tool and dye making)	• Skills pathways • Practice recognition • Africa • Australia • New Zealand • South America • Primary (economic sector)	• Self-directed • Competency and assessment approach
Courses related to a career for which registration is needed with the bodies regulating the practice (real estate, security, etc.)	• Global perspective • Skills pathways • PDF certification • Academic accreditation • Practice recognition • America • Secondary/manufacturing • Quaternary (economic sector)	

Economic Sector

The majority of the articles (52.05%) focused on MCRs in the service sectors, including tourism, banking, and health (medicine). 15.07% of the articles were in the quaternary sector, which includes knowledge-based economies such as IT, media, and research and development. However, 16.44% of the articles did not specify an economic sector. Table 13 shows that there is a global consideration of MCRs by quaternary and quinary economic sectors.

Table 13: Economic sector

	Positive correlation	Negative correlation
Primary	• High-income countries • Skills pathway integration into large qualification • Practice recognition • Courses related to one of the trades • Africa • South America	• Self-directed • Digital badge (free)
Secondary/Manufacturing	• Self-directed • Skills pathway integration into large qualification • Practice recognition • Offline (100% – includes face-to-face) – assessment delivery • Science, Technology, Engineering and Mathematics (STEM) • Accounting, Economics and Business Management • Courses related to a career for which registration is needed with the bodies regulating the practice	
Service/Tertiary	• Self-directed • Experiential (work-integrated learning) • Formative or peer assessment (assignments) • Academic accreditation • Academic recognition • Hybrid (online/offline) mode – teaching and leaning • Practice report (position paper) • Ongoing coaching track • Academic research	• Institution-directed • Practice report (position paper) • Policy paper/White Paper
Quaternary	• Global • Practice recognition • Courses related to a career for which registration is needed with the bodies regulating the practice	• High-income countries
Quinary	• Global • Skills pathway integration into large qualification • Competency and character assessment • Academic accreditation	• Self-directed • Summative (final exams) • Experiential (work-integrated learning) • Research or project-based

	Positive correlation	Negative correlation
	• Policy paper/White Paper • Education • Arts • North America	• Digital badge (free) • Hybrid (online/offline) mode – teaching and leaning • Long duration (more than 40 hours)

DISCUSSION

CONTEXT – HIGH-INCOME/LOW-INCOME COUNTRIES AND CONTINENTS

High-income countries prefer not to pay for digital badges of MCRs, nor do they place a high value on the MCRs associated with the knowledge economy. Low-income countries, by contrast, particularly those in Africa, Asia, and South America, are still at the proposal stage in creating MCRs. It is also noted that low-income countries tend to prefer MCRs that are accredited by academic institutions.

MCR implementation requires a financial investment in a skills ideal that will directly benefit an organization. Hence, the commitment of financial and non-financial resources might be a challenge for low-income countries. This tendency among low-income countries could likely represent a preference for alternative strategic priorities in low-income countries but could also represent an indifference or slowness to adapt to emerging trends.

PEDAGOGIC APPROACH

Self-directed learning is associated with free digital badges, compared with institution-directed learning, where MCRs are more associated with PDF certificates. Students are more likely to enrol for MCRs through self-directed learning at academic institutions which recognize the MCRs. It is nonetheless noticeable that MCRs, especially those that are self-directed, are a growing area of research interest.

PRACTICE AND ACADEMIC INTEGRATION

Practitioners have similarly placed greater importance on the competences acquired through practical or hands-on assessments within the practice itself.

The papers that were concerned with skills pathway integration into larger qualifications were mainly associated with courses related to trades or professional bodies, including those in the humanities and social sciences such as nursing, social work, and early childhood education (Boyd-Swan & Herbst, 2020). The trades and professional bodies have a history of continuous professional development through MCRs and have matured to the point of gaining formal accreditation with academic institutions (Hölbl et al., 2018).

COMPETENCY AND ASSESSMENT APPROACH

Unlike the trades and professional bodies, which rarely use summative assessment in preference to work-integrated-learning, academia continues to emphasize summative assessment as an important mechanism for competence evaluation, even for MCRs.

MCRs that use formative assessment are more likely to use online mechanisms and issue a digital badge.

Regardless of the context, experiential methods of assessment guided by international benchmarks are being considered to an increasing degree. This could relate to the global nature of talent today. MCRs are also looking to leverage digital technology to assess learning that has been acquired through experience. This means learning can be assessed online without learners having to be physically present, for example, by using simulations (Ruddy & Ponte, 2019). This digital capability also applies to life-long learning (within a discipline) and life-wide learning (moving across disciplines), as seen in assessments through coaching.

Communication of Completion

Digital badges are the primary means of communication of the completion of MCRs in the digital age. Digital badges are convenient and easily communicated to large audiences through platforms such as social media. Digital badges that are obtained for a fee are often based on free access to educational content but require a payment for the badge itself; online learning platforms such as Coursera generally take this approach.

PDF certificates are not particularly highly regarded in high-income countries, although they still hold value in MCRs offered in STEM, the trades, financial and human-related disciplines, and professional bodies. Professional bodies are more likely to prefer a PDF certificate as the means to communicate completion of an MCR to the use of a digital badge. This shows a preference for tradition within the professional bodies.

MCRs in Europe (unlike North America) tend towards free digital badges, which might be explained by the historically strong relationships between practice and skills development sectors, or a deliberate strategy to build momentum for MCRs (Moodie & Wheelahan, 2020). Moreover, the tendency towards MCRs that prefer digital badges for a fee in Asia might be attributed to the perception that free items are less valuable, especially in the context of employability (Resei et al., 2019). The MCRs with paid-for digital badges are often academically accredited and unlikely to be self-directed.

Accreditation and Recognition

Academic accreditation typically reflects the assurance of a standard of academic education, with this standard often a high one. Asia and low-income countries emphasize mainly MCRs that are academically accredited, which suggests a preference for high standards. This could be because both Asia and low-income countries are moving towards social and economic transformation within the Sustainable Development Goals (SDGs) so as to become more self-reliant. To that end traditional education, which has been shown to be a strong predictor of social and economic growth, is a preferred strategy. There is no evidence of the relationship between MCRs and social/economic growth against which low-income countries can benchmark.

Teaching and Learning Delivery Mode

There was little empirical research on offline MCRs, and what existed was mainly exploratory. However, while a great deal of research on MCRs places greater emphasis on digital MCRs, offline MCRs play a role in areas with poor physical and educational infrastructure, which is the case for low-income countries. It is therefore noteworthy that the online learning trend is viewed negatively in North America, in all likelihood because there is already good access to physical, educational infrastructure. Conversely, Africa, Europe and the Middle East are pushing hard for online modes of delivery due to their infrastructural shortcomings. There is a need to determine how best to teach competence-based content, research, or project-based content.

There is a strong movement towards self-directed learning on online and hybrid platforms. Content is more readily available online without the need to be physically present in the learning environment – the content can also be learnt at one's own pace. This illustrates the flexibility in skills development that MCRs afford individuals while they are engaging in other career activities.

The hybrid MCRs that are implemented mainly use practical means of assessment, that is, by means of coaching, work-integrated learning, and research/project-based assessment. The assessment strategies suggest that the hybrid MCRs focus on work-readiness. However, there are few hybrid MCRs for the quinary and the quaternary sectors, suggesting a gap and an opportunity to introduce MCRs in the government and the 4IR sector.

Assessment Delivery Mode

Some online assessments are automatically assessed and can include other mechanisms such as plagiarism checks. However, automated online assessment mechanisms suffer from some inherent shortcomings, particularly in confirming plagiarism and promoting quality assurance. These mechanisms cannot also ensure that the candidate has submitted original work (Ruddy & Ponte, 2019). Despite advances in technology, online assessment methods are not yet mature. In many instances, offline assessments are taken and made digital without integrating true online assessment mechanisms (Boud & Jorre De St Jorre, 2021). However, COVID-19 and the 4IR require a re-evaluation of the embeddedness of digital technology in all aspects of life (Karakose, Polat, & Papadakis, 2021).

Online MCRs typically offer free digital badges, while offline MCRs, especially in the secondary/manufacturing sectors, offer PDF certificates. There is, therefore, a research gap and an opportunity for MCRs to adopt true online assessment mechanisms.

Coaching offers an interesting approach related to work-integrated learning, which requires close collaboration in order for practice to become the assessment mechanism. Coaching also applies in the case of hybrid assessment, where work-integrated learning and competency and character assessment are increasingly becoming part of integrating work-readiness. This is especially important in the service sector, and a fair amount of academic research is considering coaching as an established assessment method. Free digital badges are offered to those who complete coaching tracks.

The regional differences between Africa, Europe, and the Middle East, compared with North America, are noticeable. Africa, Europe, and the Middle East are driving 4IR tech and advocating going online. It is also in these countries that the largest amount of research is conducted with regard to developing new educational systems (design science research) – though many of these remain at the proposal stage. Conversely, North America is silent on any 4IR agenda.

The hybrid assessment model has been consistently linked with the competency and character assessment models. It has also been determined that it is not enough simply to have a qualification – it is also important to show 21st-century skill competencies related to job embeddedness for a particular economic growth sector. For example, if a country focuses on information technology (IT), attention should be paid to the specific competencies in that sector.

Type of Research/Policy/Report

In as much as MCRs have been researched more compared with practice reports, the emphasis was clearly different. Academic research has focused more on accreditation and implementation of MCRs, while practice has emphasised job-embeddedness and skills pathways.

Skills Sector

The MCRs offered in the Middle East are mainly in education, and in North America they are mainly on professional bodies.

STEM MCRs (which are typically between 5 and 40 hours in duration and self-directed) and business-oriented MCRs are focused on mainly in the secondary/manufacturing sectors. MCRs in the Humanities are generally longer and emphasize skills pathways. The duration of MCRs is therefore influenced by the sector.

Education MCRs remain traditional in the sectors. This shows that existing courses are being converted for the online environment, but there is hardly any innovation. The number of hours required for Education MCRs and traditional Education courses are mostly similar. This means that the Education sector is not really innovating in line with emerging digital technologies.

The arts sector MCRs are focused on the primary economic sector and are promoted mainly as being self-directed. The government MCRs are in the arts and education.

Moreover, trade-related courses and professional bodies are strong in terms of skills pathways. The trades are emphasized mainly in Africa, Australia, New Zealand, and South America. This is likely where vocational colleges play an important role; for instance, New Zealand and Australia have always had a strong vocational training focus. These vocational MCRs are recognized by practice. In terms of informal learning, recognition of prior learning of MCRs is better recognized by practice.

The trade courses are not self-directed, nor are they competence assessed. Instead, hands-on apprenticeships or in-service training feature predominantly. MCRs are created to create pathways for learners to enter into formal education – these are the skills pathways. There is thus an opportunity to create skills pathways between trade-related courses and academic accreditation and academic recognition.

Professional body MCRs take a global perspective, as they operate at an international level – even if one relocates, the MCR is recognized. These are often well-recognized in academia and practice; hence professional bodies stand out as the glue between academia and practice. PDF certificates, and not digital badging, are important in this sector. Americans further emphasize professional body MCRs as a means of maintaining professional excellence in a highly competitive environment. This ensures that performance is maintained and well regulated. For example, the secondary/manufacturing sector is much more highly regulated than other sectors.

There is an opportunity to determine the role of MCRs in different sectors in ensuring that skills are beneficial, for example, by linking every MCR to skills, jobs and courses with entirely new career and skills pathways (an example is the Singapore skills framework).

Economic Sector

The primary sector MCRs are offered mainly in high-income countries, while Africa and South America offer clear skills pathway integrations that are practice recognized. These MCRs seldom offer free digital badges. The primary sector is typically deeply established, yet it is a sector that is increasingly experiencing a digital transformation.

The secondary sector favors primarily MCRs (mainly STEM-related, business-oriented, and professional bodies) that are self-directed, assessed offline, and emphasize skills pathway integration. These MCRs are, therefore, more regulated and more specialized. Technical/vocational colleges are thus meant to play a greater role in skills pathway integration. Both academia and practice have looked at these MCRs, but there is a gap in terms of policies on service sector MCRs.

Service sector MCRs are also self-directed and accepting of hybrid learning models with a marked skills pathway integration. This ensures that individuals understand the practice. In the service sector, assessment is focused on work-integrated learning, where skills and competencies to perform the job can be confirmed, regardless of the institution or skills sector. These MCRs are not as extensively regulated, and every institution follows its own methods. This reflects an opportunity for regulation and standardization.

Quaternary MCRs, where the 4IR is located, are taking a global perspective. This is an economic sector that is not static, but rapidly evolving. These MCRs are practice recognized; however, it is worth noting that high-income countries are not paying much attention to 4IR MCRs.

Quinary (government) MCRs also take a global perspective and are not self-directed but emphasize skills pathway integration. Character assessments are emphasized here, since these are soft skills that are particularly emphasized in the government sector. These MCRs are focused on primarily during policy stages, and government MCRs are therefore almost always academically accredited (without policy in MCRs, academic accreditation is relied upon). These MCRs are mainly in the arts and education sector.

The means of assessment in quinary MCRs are predominantly character/competence assessments, as these MCRs have not engaged with other assessment mechanisms for "soft skills". These quinary MCRs are also not taught through hybrid learning methods, there are no free digital badges, and the soft-skill MCRs are rarely long.

CONCLUSIONS, IMPLICATIONS, LIMITATIONS, AND AREAS FOR FURTHER RESEARCH

A systematic literature review was conducted to gain a holistic understanding of MCRs and how they have been considered both in academia and in practice.

It is evident that the economic status of a country or region plays a significant role in the appreciation and role of MCRs. Economies that are innovating faster, especially high-income countries and continents (Europe, North America, Australia, and New Zealand) demonstrate a greater need for skills on demand, which MCRs offer. Low-income economies appear to have a less keen interest in MCRs or for skills on demand; their interests appear different and probably more focused on other social/economic priorities. This revelation represents a widening gap between high- and low-income countries and will invariably result in a greater brain drain from low-income countries among the few that enrol for globally available MCRs.

The greatest emphasis of MCRs is clearly on providing technical and practical competence in a narrow area or specific discipline, and on fulfilling certain job demands. There is not much interest in integration into academic or entire disciplinary areas except in the trades and professional bodies. This means that disciplines without professional bodies are not adequately benefitting from the advantages that MCRs offer. MCRs therefore benefit organized disciplines to a far greater degree.

The preference for summative assessment in academia to measure the holistic understanding of an area, and the sudden rise of academic grades because of a switch to using formative assessments during COVID, bring into focus the debate between the weighting of formative and summative assessments. However, MCRs focus on a focused and narrow area, and hence formative assessment, which is easier to conduct online, is possible yet is vulnerable to plagiarism and is subject to the high cost of assuring quality.

The preference in most MCRs for self-directed learning means that learning can be paced according to the strengths and competence of the learner. This is a good thing. Nonetheless, the self-directed MCRs are rarely integrated into any particular skills pathway, which can result in a candidate having skills that do not allow them to move into another area of interest, for example, to cross over from a non-STEM career to a STEM career or vice-versa.

Tradition still plays a role in communication mechanisms; the more established professional bodies and trades prefer PDF certificates, while the emergent MCRs, often not yet organized into a discipline or society, prefer digital badges (usually free). The communicative advantage of digital badges includes easy recognizability and shareability across social media. Digital badges do not have to be physically printed and hung on the wall. The digital badge also represents a sociocultural shift in communications to social media platforms.

The emphasis on academic accreditation in low-income countries also reflects a stagnation with tradition; exclusively associating academic accreditation with high quality. Low-income countries

experience much higher levels of unemployment or have larger informal sectors which would better benefit from MCRs, yet the emphasis remains predominantly on academic accreditation. This further highlights the widening skills gap between high-income and low-income countries. This therefore presents an opportunity for research on the impact of MCRs, compared with that of traditional education, on social and economic growth.

Moreover, little research has been done on MCRs that use offline mechanisms for teaching and assessment, which could be of benefit in areas where infrastructure is poor. This again represents a widening social and educational divide as a result of digital differences.

MCRs are clearly being pulled in different directions: academia towards academic rigor represented by a preference for accreditation and recognition; and practice towards relevance, represented in their preference for job-embeddedness and skills pathway integration. This also explains why a number of organizations have chosen to create their own learning academies rather than wait for skills from academia and having to retrain them. There is, therefore, an opportunity for academia and practice to find each other.

There is a glaring gap in the non-STEM and Education-related disciplines, even though most Education MCRs consist mainly of digitized content, that is, the content is digitized without much change in the way it is delivered. This is probably also related to the shift in work to more STEM-related disciplines as a result of the 4IR.

Limitations

The study had a wide scope, and the consequent length requirements for a publication means that some other results and findings were not considered. Another limitation was the exclusion of content in languages other than English, which immediately narrows the generalizations, excluding French, Arabic, Mandarin, Hindi, Spanish, and other major world languages.

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APPENDIX A: CODE DESCRIPTION (CODING FRAMEWORK)

Classification	Description	Code
Context	High-income countries	1A
	Low-income countries	1B
	Global context	1C
	Not explicitly mentioned	1D
Pedagogic approach	Self-directed	2A
	Institution directed	2B
	Not explicitly mentioned	2C
Practice and academic integration	Job embeddedness / Career pathways	3A
	Skills pathway integration to large qualification, e.g., degrees (credit pathways)	3B
	Competence based	3C
	Not explicitly mentioned	3D
Competency & assessment approach	Formative or peer assessment (assignments)	4A
	Summative (final exams)	4B
	Experiential (work-integrated learning)	4C
	Research or project based	4D
	Competency and character assessment	4E
	Not explicitly mentioned	4F
Communication of completion	PDF certificates	5A
	Digital badge (free)	5B
	Digital badge (for a fee)	5C
	Not explicitly mentioned	5D
Accreditation and recognition	Academic accreditation (formally recognized by academic institution)	6A
	Practice accreditation (practice qualification, e.g., Google, Cisco, Microsoft, IBM)	6B
	Academic recognition (recognized by international benchmarks)	6C
	Practice recognition (endorsed by practice)	6D
	Not explicitly mentioned	6E
Teaching and learning delivery mode	Online (100%)	7A
	Offline (100% – includes face to face)	7B
	Hybrid (online / offline) mode	7C
	Not specified	7D
Assessment delivery mode	Online (100%)	7E
	Offline (100% – includes face to face)	7F
	Hybrid (online / offline) mode	7G
	Ongoing coaching track	7H
	Not specified	7I
Status of implementation	Implemented	8A
	Proposal stage	8B
	Not specified	8C
Study duration	Less than 5 hours	9A
	Short duration (5 hours to 40 hours)	9B
	Long duration (more than 40 hours)	9C
	Not specified	9D

Classification	Description	Code
Research approach	Qualitative	10A
	Quantitative	10B
	Design science	10C
	Exploratory	10D
	Theoretical / Conceptual	10E
	Explanatory	10F
	Case studies	10G
	Survey	10H
	Mixed method	10I
	None	10J
Type of research / report / policy	Academic research	11A
	Practice report (position paper)	11B
	Policy paper / White Paper	11C
Skills sector	Science, Technology, Engineering and Mathematics (STEM)	12A
	Accounting, Economics and Business Management	12B
	Humanities and Social Sciences	12C
	Education	12D
	Arts	12E
	Courses related to one of the trades (such as for plumbers, electricians, tool and dye makers etc.)	12F
	Courses related to a career for which registration is needed with the bodies regulating the practice) (estate agents, security etc.)	12G
	Not specified	12H
Continent	Africa	13A
	Asia	13B
	Australia	13C
	Europe	13D
	Middle East	13E
	North America	13F
	South America	13G
	Not Specified	13H
Global economic growth sectors	Primary (extraction of raw materials, e.g., mining, agriculture, mining, forestry, grazing, hunting and gathering, fishing, and quarrying)	14A
	Secondary / manufacturing (producing finished products, e.g., construction, electricity)	14B
	Service / tertiary (intangible goods and services to consumers, e.g., tourism, banking, schools, medicine)	14C
	Quaternary (knowledge economy, e.g., information technology; media; research and development)	14D
	Quinary (government, policy)	14E
	Not specified	14F

APPENDIX B: CORRELATION TABLE

This spreadsheet can be downloaded from the paper's landing page at https://doi.org/10.28945/4954

APPENDIX C: SUMMARY OF PAPERS

No.	Author	Year	Country	Summary of paper and key findings
1	Coyne et al.	2019	Not specified	There is inadequate training or professional development available for preparing teacher leaders. Integration of micro-credentials has been identified as a solution to prepare teacher leaders.
2	Kato, Galán-muros and Weko	2020	USA	Credentials cannot be seen as a substitute for formal post-secondary education qualifications, but to complement prior education, experience, and training as most employers still seem to view a degree as an indication of an individual's skills and knowledge.
3	Elliott, Clayton and Iwata	2014	New Zealand	Digital micro-credentials can be used as valid indicators of accomplishment, skill, knowledge, or interest and can further be used for certification purposes. The paper mentions two distinct approaches to awarding digital badges to recognize, validate and reward learners. The authors also argue that a micro-credential and ecosystem would provide the institution with both the infrastructure and framework to empower learners and employees to create a holistic view of their achievement through the pictorial display of an earned micro-credential badge collection.
4	Copenhaver and Pritchard	2017	USA	Students are motivated and encouraged by the recognition they receive as a result of micro-credentials.
5	Rubleske and Cata	2017	USA	University micro-credentials can benefit students in the following manner: • students can learn and acquire the skills that employers currently need • students can market themselves effectively to employers • micro-credentials can assist students to manage their academic and professional profiles • micro-credentials can motivate students by providing clear goals and tracking progress
6	Ghasia, Machumu and DeSmet	2019	Tanzania	Both lecturers and students are confident that micro-credentials will encourage lifelong and connected learning. However, to leverage this opportunity, the creation of a micro-credentials ecosystem, formulation of strategies and policies, and deployment of the necessary infrastructure is recommended.
7	Tomlinson	2008	United Kingdom	Students view their qualifications as having a declining role in securing employment opportunities in a competitive labor market. While micro-credentials are still seen as a significant dimension of their employability, students suggest a need to add value to them to gain an advantage in the labor market.
8	Gauthier	2020	USA	Practice is not satisfied with employee skills; competency is the new currency; seat time does not equal education; a policy for issuing and securing micro-credentials is necessary.
9	Mathur, Wood and Cano	2018		Employers seek employees who demonstrate mastery of transferrable skills. Digital badging, or micro-credentialing, authorized by academic institutions, is a novel way for doctoral students to demonstrate the acquisition of transferrable skills to potential employers.
10	Bartz and Kritsonis	2019		Micro-credentialing is an appropriate method for delivering outcome-based learning tailored to the needs of individual teachers using the Individualized Professional Development approach.

No.	Author	Year	Country	Summary of paper and key findings
11	Vogtenhuber	2018	21 countries	Countries with vocational-specific education systems demonstrate higher levels of inequality in skills attainment among their workforce. Practice credentialization is particularly high in countries with a large combined school and workplace-based education and training sector. The paper proposes a vocational education system, measurement of human capital skills, acquisition, and occupational outcomes at both individual and country level.
12	Kogan	2011	Serbia	No clear hierarchy with regard to educational credentials is evident when it comes to entering unregistered employment. Among those who are successful in entering employment, higher education is a predictor of joining the ranks of the registered sector. The role of credentials versus contacts depends on the character of the job targeted. School dropouts are likely to find employment in the informal sector, which is often labeled as unregistered employment, hence Serbian graduates are less attracted to informal employment.
13	Brown and Bills	2011		Completed degrees are exponentially different from credit hours earned (without a degree) in terms of exchange value. Credentials may be sequenced or not and may vary in terms of the length of time required to acquire them.
14	Hickey et al.	2014		Credentialing in nursing can improve health care quality. Individuals seeking a certification credential are motivated to pursue continuing education, and organizations seeking credentialing look to hiring individuals with credentials.
15	Boyd-Swan and Herbst	2020		NAEYC-accredited providers are consistently more attracted to higher-quality jobseekers than nonparticipants, while those participating in QRIS (quality rating programs) are not. Organization accreditation is primarily useful during the first few years after a provider opens for business. Each of the professional development bundles is preferred to the baseline bundle. Those with professional credentials are preferred to those without and are likely to be called for an interview.
16	MacBeth et al.	2016	Australia	Non-credentialed infection control professionals (ICPs) identified barriers to credentialing as no employer requirement and no associated remuneration. Credentialed ICPs demonstrate a number of characteristics, including higher education, more experience in infection control, and being better resourced than their non-credentialed colleagues.
17	Everhart et al.	2016	UK	Loss of credits, which often happens in transfers from associate programs to other programs, is a predictor of degree non-completion, especially among low-income, first-generation, and part-time students.
18	Pham and Khan	2020		Introduced a Bayesian-based method to estimate probabilities of knowing concepts at Bloom levels given responses of students to evaluate student comprehension and skill levels. The method can offer students feedback on strengths and weaknesses, as well as advising instructors to design sufficient assessments that accurately measure the required skills of concepts to accomplish course objectives.
19	Song	2019		Students are more likely to participate and complete the daily exercises and perform better in informal tests. In addition, using deliberate questions based on micro-credentials can provide instructors with information on students' overall competencies with regard to various micro-credentials, thus allowing instructors to design interventions accordingly.

No.	Author	Year	Country	Summary of paper and key findings
20	Lux et al.	2019		The study proposed a full-text search framework based on the publicly available metadata on the Hyperledger "Indy ledger" for retrieving matching credential types. The proposed solution is able to find credential types based on textual input from the user by using a full-text search engine and maintaining a local copy of the ledger.
21	Lim et al.	2018		The study highlights six broad possibilities to implement micro-credentials in undergraduate programs across the university. It includes micro-credential design and assessment principles, information pack and platform as well as outlining the student's journey in each of the phases involved in the micro-credential ecosystem.
22	Arenas and Fernandez	2018		The study proposed a blockchain-based solution, 'CredenceLedger', which stores compact data proofs of digital academic credentials in a blockchain ledger, making these easily verifiable by education stakeholders and interested third party organizations.
23	Karlin, Allendoerfer, Ulseth, Bates, and Ewert	2016		The findings showed that the most common barriers to widespread educational innovation can be framed as credentialing issues, whether as excuses for not implementing change or as legitimate obstacles. At the root of the credentialing issue is the ubiquitous standard unit of effort – the credit hour, which was originally designed simply to measure faculty workload rather than student learning.
24	Young et al.	2020		As the program evolves to better meet the needs of its stakeholders, we find that both participants (badge earners) and the issuer (National Instruments) see potential value in the National Instruments Badging Program. The value for both seems to stem from how the program enables the sharing of badges, which helps the earner establish their skills/reputation while also increasing awareness of the program for National Instruments.
25	Casilli and Hickey	2016		This article shows how the informational affordances of digital badges are transforming education and learning generally, and more particularly by transcending conventional paradigms of academic credentialing and educational assessment.
26	Murawski	2019	USA	For employers, identifying new and current employees with specific skills will become increasingly important as technology continues to advance. To attract skilled workers, employers could emphasize their preference for employees who understand the value of lifelong learning and demonstrate this value by participating in programs that include stackable credentials. For job seekers and workers, stackable credentials open the door for employment and advancement. Ultimately, communities benefit from a more competent, skilled workforce that is better able to protect public health and the environment.
27	Alexander and Neill	2018	England	Children and teachers reflected on the badges positively as tools that are able to build perseverance, develop emotional awareness, build relationships and enhance skill and knowledge acquisition. Some participants, however, raised vulnerability and safeguarding issues, and we explore the implications of these for future practice.

No.	Author	Year	Country	Summary of paper and key findings
28	McDermott, Donlan, and Zaff	2019	USA	These authors investigated whether there were differences in self-control, persistence, and social relationships among youth with a diploma, a GED, or no credential. They then investigated whether and how self-control, persistence, social relationships, dropout status, and educational attainment related to young adults' employment outcomes. Results indicate differences in self-control, persistence, and social support among the three groups. Models indicate a non-linear relation between self-control and persistence to employment outcomes, and highlight the importance of educational attainment.
29	Dyjur and Lindstrom	2017	Canada	Results of the study indicated that many participants had positive perceptions of the badges, finding them authentic and innovative. Some participants had negative or mediocre perceptions of digital badges, finding them less prestigious than a certificate of completion. Badge appearance may have had an impact on perceived credibility.
30	Ruddy and Ponte	2019	Australia	This article addresses the development of an academic integrity awareness micro-credential for new student entrants to university.
31	Thrasher, Walker, and Hankemeier	2018		Newly credentialed athletic trainers feel prepared overall to assume their roles as graduate assistants in the collegiate setting. New athletic trainers desire rigorous professional education programs and hands-on clinical experiences to better prepare them for their roles. Inconsistencies exist between the myriad of skills learned in the classroom setting and experienced in the clinical setting, in which some skills learned in the classroom are never experienced clinically.
32	DiGaudio and Bickmore	2019	USA	Although state credentialing officers indicated the value of a specific middle grades principal credential, the need for flexibility for districts and credential candidates was the overarching reason for eliminating or not having a middle grades administrative credential.
33	Zaccagni, Paul, and Dantu	2019	USA	This paper presented a way to help match employers' knowledge requirements with students' knowledge earned using blockchain's smart contracts to assure credentials and track student records.
34	Jefferson, MacKenzie, Hackley, and Perlman	2020	USA	The results of the survey are encouraging and demonstrate that the majority of respondents have accurate knowledge about US midwifery credentials. However, ACNM members not involved in any leadership role scored significantly lower on the survey and may benefit from targeted education to better understand US midwifery credentials. This may improve midwifery in the United States by engaging midwives in discourse about the profession.
35	Cubric and Cubric	2016	Croatia	Based on the reported experiences, it is to be concluded that the concept and technology of OBs, coupled with appropriate pedagogical approaches, could be a viable solution for teaching, assessing, grading and recognizing soft skills.
36	McDaniel	2016	USA	Understanding the relationships between formal completion logics and the psychological experience of badging allows designers to better design, deploy, and critique badging systems, leading to more effective implementations within simulation and gaming contexts.
36	Abramovich	2017	USA	The findings from this study indicate that learning opportunities for ultra-Orthodox Jewish girls can be improved through the inclusion of digital badges as an assessment. Specifically, digital badges can support motivation, formative and summative feedback, and credentialing for learning among ultra-Orthodox Jewish girls.

No.	Author	Year	Country	Summary of paper and key findings
38	Kim, Zhang, Chung, Kim, and Choi	2020	South Korea	The findings suggest that in view of workplace discrimination, women are more likely to value credentials, believing that credentials could help them overcome the disadvantage imposed on them because of their gender, catch up with men, and minimize their risk of failure, as education was perceived to provide equal opportunities for men and women.
39	Van Der Meer	2011	Netherlands	The main findings of the analysis are that on the one hand degrees are seen as a credential, i.e. the effects of educational degrees outweigh the effect of years of education, but that on the other hand investments in education lead to positive external effects. Therefore, the social return of education is higher than the private return.
40	Borras-Gene	2018	Madrid	This article reports a proposal for implementing Open Badges for the accreditation of training courses and the results achieved over a one-year period.
41	Demonte	2017	USA	This report elaborates on how micro-credentials have gained popularity for teacher professional development.
42	Fishman et al.	2018	USA	The report presents the findings of the NSF-funded workshop on the promise and pitfalls of using digital micro-credentials.
43	Resei et al.	2019	Europe	The goal of this report is to provide an overview of the status quo of micro-credentials (both in the EU and globally), focusing on MOOC-based micro-credentials in particular.
44	UNESCO	2018	Globally	The objective of the research was to (i) map the key initiatives in the area of digitization of learners' records, verifications of credentials and certifications; (ii) outline the ecosystem of these tools; (iii) identify divergence and convergence and implications on recognition of qualifications, verification, and quality assurance; and (iv) identify implications and links with the work on WRLs.
45	Jackson & Willis	2014	UK	This paper suggests that a model for life-wide learning awards where the assessment activities are devolved to trusted third parties would help to reduce the burden on students and staff. The idea of Open Badges, a standard for creating and sharing secure, verifiable digital credentials and evidence, is proposed and discussed using a case study as a means to support a devolved approach to life-wide learning awards.
46	Halavais	2013	USA	The paper looked at how easily micro-credentials can be shared, collected and observed online to see what this tells us about credibility, experience, and social boundaries.
47	Smith and Day	2015		The study adopted a mixed method to explore the impact of FDC on work-related self-efficacy beliefs. Findings suggest that FDC training improved self-efficacy in human service workers and that the absence of training allowed negative self-efficacy beliefs to grow.
48	Lubicz-Nawrocka	2016	Scotland	The case study discusses how the Open Badge Scheme was implemented to recognize the training, development, and achievement of competencies.
49	Ferguson	2015	USA	The project took the eloquence and innovation of digital badge technology and adapted and applied it to the more rigorous and demanding quality assurance credentialing framework. IREC contracted with a digital badging software platform to develop and issue digital credentials to two categories of its credential holders. This pilot was intentionally limited to a small sample to explore both the process and response.

No.	Author	Year	Country	Summary of paper and key findings
50	Randall and West	2020		The study found that use of the term "micro-credential" instead of the term "digital badge" did not have a significant effect on employers' perceptions of open badges. The study assumed micro-credentials and digital badges to be the same thing.
51	Mohamed (Malaysian Qualifications Agency)	2019	Malaysia	The purpose of the report is to provide HEPs and relevant stakeholders with information on principles and good practices in the implementation of micro-credentials. Specifically, this guideline is intended to encourage, support, and guide all types of micro-credentials (MC) offered by HEPs.
52	Sundari	2017		The study found there to be a lack of knowledge among nurses, a lack of management knowledge related to the credential system, and a lack of policy alignment, leading to problems in the implementation of the credential system.
53	Carey and Stefaniak	2018	USA	The paper discusses digital badges as micro-credentials. It is an exploratory paper that considered the expert opinion of micro-credential proponents in higher education institutions. The findings are varied, with some skepticism expressed, in that micro-credentials are still in their early formative years.
54	Rennie Center for Education Research & Policy	2019	USA	The report examines pilot studies on accrediting competencies gained in non-formal education using micro-credentials and digital badges, and reports on the results of those efforts. A proposal on how to accredit the competencies using an open badging system is formulated.
55	Kim, Zhang, Chung, Kima and Choi	2020	Korea	The paper investigated gender-based perspectives on credentials. The study found that women valued micro-credentials due to the existence of gender inequality. It was stated that credentials could be used • as a tool or weapon of empowerment for women, assisting them in overcoming the discrimination they face, or • as a means to reduce inequality by allowing men and women to compete on an equal footing for a good job, or • as a low-risk investment that provides security for women.
56	Assirelli	2015	18 countries, of which 13 are European	The purpose of the paper was to investigate the influence of labor markets on credentials and skills. The paper recommended that the skills mismatch be differentiated from the micro-credential mismatch.
57	Gainsburg	2012	USA	The findings of the study suggest that the route to regular implementation of university-promoted mathematics-teaching practices requires neither complicated nor revolutionary changes to teacher education.
58	Brown and Souto-Otero	2018	UK	The paper suggests that formal academic credentials play a relatively minor differentiating role in the UK labor market, as the majority of employers place greater emphasis on job readiness.
59	Hölbl et al.	2018		The paper suggests that the digital platform enables educational institutions as well as other potential stakeholders such as companies, institutions, and organizations to manage, assign and present credentials.
60	Hudd, Bollmeier, and Seoane-Vazquez	2014	USA	The study aimed to learn more about pharmacists who have earned the AE-C credential. The study found that professional advancement improves confidence.

No.	Author	Year	Country	Summary of paper and key findings
61	Dismore	2014	England	The paper focused on the credential landscape itself, how employers perceived higher education qualifications, and how higher education institutions perceived vocational qualifications.
62	Lam Cham Kee and Tran	2020		The paper looked at the impact of POCUS among physicians.
63	Risner and Anderson	2015	USA	The study looked at how teaching artists perceive the need and usefulness of a credential program specifically designed for teaching artists in dance and theatre arts.
64	Crites	2017		The paper looks at a growing need for experts in behavior analysis to provide services in early intervention programs, schools, day treatment centers, institutions, and in the workplace. A board-certified behavior analyst (BCBA) is credentialed to provide these behavior analytic services.
65	Delello et al	2018	USA	The study suggests that although students found the badges motivating, learning the course content and the overall course grade were more important to them than the tangible reward. The successful implementation of digital badges in higher education requires advanced planning to promote awareness among students of the usefulness of digital badges.
66	Mihalyi and Tatrai	2019	Europe	The article gives an overview of open badges, a type of micro-credential that has gained popularity in Europe recently as a means to recognize non-formal and informal learning actions and outcomes. The paper further highlights areas where open badges can be used.
67	Chen, Martin and Erdosi-Mehaffey	2017	USA	The findings revealed that having the NJITC coursework offered through an onsite PD model and supported by a state-based scholarship program provided much-needed incentives encouraging participation. It also resulted in improved professional growth and practice among the participating practitioners.
68	Banargee and Lee	2012	Canada	The study results indicated the gap between recent immigrants and native-born Canadians.
69	Horner, Childress, Fantus and Malek	2020		The study proposed a more robust evaluation process for validation of credentials to attest to the achievement of competency.
70	Ooi, Jaafar and Baba	2017	Malaysia	The study identified the need to study and investigated the various credentials for status and job satisfaction.
71	Digital Promise	2017		The study recommends an ecosystem that: 1. Creates incentives for local educators to experiment with different forms of currency for earning micro-credentials; 2. Establishes professional development processes and work schedules that provide teachers with more time and support to engage in long-term inquiry required by most micro-credentials; 3. Encourages everyone in the system – teachers, paraprofessionals, and administrators – to participate in micro-credentials in ways that encourage team learning and leadership development; and 4. Invests in innovative and adaptive platforms that offer educators voice and choice in how they use micro-credentials that suit their particular needs.
72	Edgecombe and Sanders	2018	USA	This working paper found differences in the alignment between high-employment industries and the production of credentials in certain fields. The study suggested financial considerations when implementing credentials for learner earning low wages.

No.	Author	Year	Country	Summary of paper and key findings
73	Credential Engine	2019	USA	This report looks at 17 credential categories offered by four types of education providers: postsecondary educational institutions, massive open online course (MOOC) providers, non-academic organizations, and secondary schools. Postsecondary institutions were found to be the largest type of credentialing organization, closely followed by non-academic organizations.
74	MicroHe	2019	Europe	The main purpose of the study was to create a briefing paper to identify the main methodological and operational challenges in recognizing micro-credentials for the purposes of both academic recognition and employment. It is based on a set of interviews with key stakeholders (students, institutions, governments, and employers) at regional, national and European levels and identifies the areas in which current European recognition instruments fall short.
75	Taha and Zakaria	2020	Germany	The paper looked at how using Ethereum blockchain can provide verifiable credentials, allowing employers to verify candidates' credentials instantaneously. The authors emphasized the importance of issuing verifiable certificates.
76	Brauer, Korhonen and Siklander	2019	Finland	The paper focused on challenges and opportunities involved in badge-driven learning from the perspective of professional development. The context of the study was higher education, particularly competence-based vocational teacher education, but the findings may be viewed in the general context of digital open badge-driven learning.
77	Wasilowski	2012	USA	The purpose of the report is to optimize existing SPCC policies that might have an impact on retention, completion, and employability for students, families, and communities in the long term. The paper makes a recommendation on a strategy to improve retention and close the gap to completion.
78	Friedler	2018	Israel	The paper recommends that course participants be issued a graduation certificate (digital badge) which allows for the accumulation of credit hours.
79	Sunıkova´, Kubincova, Simionescu and Popescu	2017	Romania	This paper introduces an approach for using peer assessment augmented with digital badges in a project-based learning scenario.
80	George and Chaze	2012	Canada	This paper focused on trained engineers in Canada and their experiences in the credential assessment process. The findings suggest that internationally trained engineers are not well informed about credential recognition and licensing processes in Canada. The study also found that credential assessments from professional bodies are likely to be more important.
81	Hickey, Unruh, Newhouse, Koithan, Johantgen, Hughes, Haller and Lundmark	2014	USA	This article proposes a conceptual model in which both credentials and standards are posited to affect outcomes in health care.
82	Gabre, Flesher and Ross	2017	USA	The purpose of the study was to investigate the perception of accountants of the CPA credential.
83	Fraser and Naik	2012	Canada	The paper looks at issues relating to training that has not been recognized by an accredited national certifying body.
84	Shwartz	2018	Israel	This article looks at how practice can internally implement micro-credentials for CPD or to upskill their employees.

No.	Author	Year	Country	Summary of paper and key findings
85	Graebe	2019		This article investigated how nurse planners, nursing professional development practitioners, and any individual who is responsible for the facilitation of learning and professional development in health care can use a competency-based education framework as a methodology to design and evaluate outcome-based continuing education.
86	Young, West and Nylin	2019		This paper reveals value for both issuer and earners that stems from the way in which the program enables the sharing of badges, which helps the earner establish their skills/reputation while also increasing awareness of the program for National Instruments. This study adds to our understanding of why an organization may find value in offering open micro-credentials as an alternative to traditional professional development and certificates for their customers and employees.
87	Tucker, Pearce, Bruce, McCoy and Mills	2012	USA	The study recommends further investigation to better understand the relationship between practice awareness and market penetration of a rating system, direct reinforcement of a credential through requirements of a rating system, and perceived value by practice professionals. The application of policy in mandating the use of rating systems with which credentials are associated may also play a role.
88	Parks, Parrish, and Taylor	2018	USA	The paper outlines 3 primary motivations for a digital credential strategy: 1. to clarify the role digital credentials play in the student lifecycle and job marketplace; 2. to outline the responsibilities of the Office of the Registrar in the development of these credentials; 3. to offer guidelines for the continued success of that development.
89	Kim and Chatterji	2019	USA	This study found that women held job-required credentials in higher esteem than men did. While slightly higher percentages of men than women held credentials at or below college level, at an associate degree level or higher, women held credentials at persistently and substantially higher rates than men.
90	Shan	2013	Canada	This paper departs from a managerial orientation towards recognition. Building on recognitive justice, it proposes an alternative anchoring point for recognition practices: the standpoint or everyday experiences of immigrants. This approach is illustrated with a qualitative study of the credential recognition practices of the engineering profession in Canada.
91	Mathur, Wood and Cano	2018		Digital badging, or micro-credentialing, authorized by academic institutions, is a novel way for individuals to demonstrate the acquisition of transferrable skills to potential employers.
92	McDaniel, Lindgren and Friskics	2012		This paper describes an online course management system (titled Adventures in Emerging Media) designed to allow students to choose their own pathways through learning content (a choose-your-own-adventure online course).
93	Borrás-Gené	2018	Spain	This article reports on a proposal for implementing open badges for the accreditation of training courses and the results achieved over one year.
94	Abramovich	2016		The paper provides an argument as to why digital badges in higher education should be used as an assessment tool and not only as a credentialing mechanism.

No.	Author	Year	Country	Summary of paper and key findings
95	Taylor-Fujikawa and Andrist	2019	UK	This paper suggests that a model for life-wide learning awards where the assessment activities are devolved to trusted third parties would help to reduce the burden on students and staff. The idea of open badges, a standard for creating and sharing secure, verifiable digital credentials and evidence, is proposed and discussed using a case study as a means to support a devolved approach to life-wide learning awards.
96	Alexander and Neill	2018	England	The paper aimed to achieve the following: 1. To explore the experiences of children and young people of engaging in and completing digital badges 2. To investigate the psychosocial effects of participating in/completing digital badges with peers and teachers The paper suggests that digital badges are a valuable health-related pedagogical tool for use with children, with the scope to be implemented more broadly in educational contexts and to be applied in other health-related domains.
97	Dowling-Hetherington and Glowatz	2017	Ireland	The study finding revealed some evidence that digital badges can make a positive contribution to student engagement within a module, particularly where they are directly linked with the module assessment requirements. Overall, digital badges have the potential to be a highly effective pedagogical tool that can also have a positive impact on the learning experience more generally.
98	Dunning, Slenning, Tickel and Dorman	2020	USA	The paper presents the 2-week VCR course that combines lecture, online, experiential, and group exercises to meet entry-level federal credentialing requirements.
99	Cucchiara, Giglio, Persico, and Raffaghelli	2014	Italy	In this paper, the digital badge ecosystem demonstrates how digital badges can be used to promote SRL, a key component in the framework of Skills for the 21st Century.
100	SUNY New Paltz		USA	The report recommends the following guiding principles for creating micro-credentials: 1. Academic quality is paramount for micro-credentials, and faculty governance participation is required. 2. Micro-credentials are initiated locally, developed, and approved according to local campus policies and procedures, consistent with campus mission and strategic goals. 3. Micro-credentials designed to meet market needs should be informed by current data from appropriate markets and align with relevant practice/sector standards. 4. Micro-credentials can provide opportunities for practice/education connections and partnerships.
101	Wilson	2016	50 states/countries	The study noted the importance of a policy that supports the funding of stackable micro-credentials. There is an opportunity for coalition/collaboration among different industries.
102	Murawski	2019	USA	The study looked at how stackable credentials lead towards a degree.
103	Malczyk	2019		The paper focused on self-care badges and their benefits.

No.	Author	Year	Country	Summary of paper and key findings
104	McCarthy	2017	USA	There should be a driving policy behind micro-credentials. When these credentials are being implemented, the following questions need to be considered: 1. How long should the credential take to acquire? 2. What skills and competencies should it cover? Who should be eligible for it? 3. How much should it cost? 4. Who should pay for it and how? 5. How long should it last? 6. Who should issue it? What impact will it have on the existing and future workforce?
105	Khoo	2019	Not specified	This paper reflect on the work od Collins. Collins attempts to escape the legacy of structural-functionalism through conflict sociology or predictions of systemic crisis. This is contrasted with the attempt by his contemporary, Herbert Gintis, to construct a transdisciplinary social science. The key problem of marketized inequality is linked to the sociology of absences in conflict sociology, and it is argued that inequalities of class, race and gender, and coloniality in higher education and credentialism can no longer be ignored.
106	Song	2018	Not specified	This paper presents one instructor's course evaluation and redesigning process, showing that micro-credentials can help instructors identify the topics which are not covered sufficiently thoroughly. The process presented in this project could also be used to align the course designs of different instructors on the same course.
107	American Council on Education (ACE) Center for Education Attainment and Innovation		USA	1. What are connected credentials? 2. Problems associated with disconnected credentials.
108	Cooley, Brantlinger, Hannaford-Simpson and Shahid	2019	USA	This paper examines the unique role that mathematics education and its credentials play in the stratification of educational opportunities and career paths in US society.
109	Dyjur and Lindstrom	2017	Canada	The findings of this paper suggest that the badge's appearance affects its perceived credibility. Participants who indicated that they would use their digital badge identified a wide variety of uses, such as sharing them through social media and printing out a hard copy certificate.
101	La	2015	UK/USA	This paper details the evaluation of the 2013 pilots that informed the development of a suite of free employability and skills BOCs in 2014 that are assessed by means of Moodle quizzes. It also discusses why the university sees the growth in free, 'soft' accreditation to be of strategic importance against a backdrop of MOOC providers issuing certification for a fee.
102	Papadakis and Cheney	2019	USA	This report indicated that both the breadth and number of credentials had expanded substantially, with the count more than doubling the preliminary estimate made in 2018. This work can inform both policy and practice in the education and workforce fields. However, to truly leverage this new knowledge, an even more rigorous accounting and a better understanding of the value and relative returns of various credentials are needed.

No.	Author	Year	Country	Summary of paper and key findings
103	Oliver	2019	Not specified	The study looked at how micro-credentials can work for different stakeholders. This report suggested that there should be some clear definitions and clarity about the standards required, particularly when micro-credentials earn admission to or credit towards formal qualifications.
104	Newby and Cheng	2019	USA	The study offered ways to improve learning performance with the support of digital badge technology and stated implications for future scholarship in this area.
105	Mook and Overdevest	2020	Global	The study looked at how fairtrade can be implemented as a credential.
106	Leventoff	2018	50 countries	This study was conducted as a base scan. The findings revealed a lack of comprehensive data with regard to non-degree credentials. Thirty-six states reported having individual-level data on for-credit certificates from public two-year institutions in their state. Twenty-seven states reported having most or all data about registered apprenticeship certificates, and twenty-two states reported having most or all licensing data.
107	Dunshea and Morphet	2015	Australia	This study explored the concept of credentialing and examined the benefits of and barriers to introducing emergency nurse credentialing in Australia.
108	Brody, Skipper, Chaffee, Wooldridge, Kicklighter, and Touger-Decker	2015	Not specified	The study developed an advanced practice credential for registered dietitian nutritionists.
109	Chartrand, Freeman, Gallersdörfer, Lisle, Mühle and van Engelenburg		Various countries	This White Paper presents the design considerations of the system architecture. It serves as the foundation for the development of reference implementations, software libraries, and deployment prototypes by the participating universities. It describes the technology choices we are making, the tradeoffs they come with, and the state of our current thinking.
110	Chaney, Paravattil, Lysoby, Rehrig, Elmore and Gambescia	2013	USA	The purpose of this article was to offer a summative report of the applications submitted for the Experience Documentation Opportunity.
111	Cerfolio and Wei	2015	USA	The study looked at how credentials can be used for robotic thoracic surgery.
112	Buchem	2017	Germany	This study looked at how open badges can be used as a tool to support multiple forms of assessment and recognition of competencies and literacies.
113	Boon, Marzuki, Jaafar and Baba	2017	Malaysia	The purpose of the study was to examine the difference between school counselors' professional credential status and job satisfaction and to set out the reasons for a lack of interest in obtaining the professional counselor credential under the governing body.
114	Ahluwalia, Lambert and Branon	2019	Not specified	The paper identified the following areas for attention: • metacurriculum over a 60-year working life • learner services • policies and funding • credentials • The New Academic Tech Stack

No.	Author	Year	Country	Summary of paper and key findings
115	Araujo, Santos, Pedro and Batista	2017	USA	The study looked at how digital badges can enhance education.
116	Araki	2020	26 countries	The paper investigated the link between credentials, skills, and labor market outcomes against a background of societal-level educational expansion and skills diffusion. The study showed that both credentials and skills generally contribute to occupational and monetary rewards.
117	Quintyne-Collins, Vescent, O'Donnell, Slepak, Brown, Allen and Ruther	2019	USA	This study provides requirements for designing digital credential wallet design and recommends guidelines on key management of DCWs.
118	Perdue	2018	USA	This policy paper focused on a new model for workforce training bringing together education (university and colleges), practice, and government to provide guided credential programs using blended learning and supporting career pathways. The policy proposed new workforce training programs using micro-credentials and a funding model to support them.
119	Mishra, Kalla, Singh and Liyanage	2020	USA	The paper proposed blockchain technology to resolve security issues relating to the sharing of students' credentials.
120	McGovern	2019	Not specified	The study found that digital badges are aligned well with adult lifelong learning. Badges can further improve adult student access to higher education, and assist in reducing fraud related to credentials.
121	McMaster and McGirr	2019	New Zealand	The paper recognized the importance of life-long learning and the use of credentials to drive it. The study also examined how credentials can support transferable skills.
122	McDaniel and Fanfarelli	2016	Not specified	This article analyzes digital badges through mechanics and psychology. The study further proposed a model that provides additional insight about badges and recommends design strategies to complement scholarship opportunities. The authors also mentioned the importance of the development of a taxonomy for a digital badge design.
123	Lumina Foundation	2015	Not specified	This report presented the beta credential framework that was developed on behalf of Lumina Foundation. The framework is also evaluated. The framework focused on building the system for communicating about and connecting diverse credentials using learner credentials.
124	Maas, Heather, Do, Brandman, Koller and Ng	2014	Not specified	The paper suggested the use of credentials for top-quality courses (such as a bachelor's degree) to support life-long and life-wide learning.
125	Hongxia	2013	Canada	The paper looked at credentials as an option for training immigrants from other countries.
126	Hagans and Powers	2015	USA	This article describes the use of single-subject research design as a method of assessing the impact of credential candidates on K-12 student learning, especially as it relates to meeting the instructional and behavioral needs of diverse students.
127	Facey-Shaw, Specht, Rosmalen and Bartley-Bryan	2020	Not specified	The study recommended further research on whether gamification, through the use of digital badges, can instill motivation and improve student results, specifically in challenging domains such as programming.

No.	Author	Year	Country	Summary of paper and key findings
128	Biles, Plass and Homer	2018	USA	The purpose of the research was to identify the effect of badges on cognitive and motivational outcomes in games for learning and to investigate whether different types of badges would result in different cognitive and motivational outcomes.
129	Rossiter and Tynan	2019	Not specified	The report provided guidelines on designing and implementing micro-credentials.
130	Ross	2016	USA	This report gives a summary of micro-credential goals and issues as these relate to different programs. The study highlighted the implications of designing a micro-credentialing ecosystem.
131	Xu and Ran	2020	Various countries	The study found that the majority of students enrolled in noncredit programs tend to be adult learners and are typically from a lower socioeconomic background than credit students at community colleges. However, half of those enrolled tend not to complete the programs.
132	US Department of Education	2016	USA	The report presents the employment status of postsecondary completers.
133	Truesdell and Birch	2013	USA	The study presented some guidelines on integrating interactive instructional technology in teaching credential programs.
134	SUNY Micro-Credentialing Task Force	2018	USA	The report recommended that micro-credentials should benefit from federal financial aid, and explored a system-wide approach to digital transcripts that include micro-credentials. The report also recommended key stakeholders to involve when designing micro-credentials.
135	Shahriar, Peletsverger, Zafar, Bailey & Johnston	2016	USA	The study introduced the concept of digital-based learning within the cybersecurity space.
136	Ruth and Yi		USA	The paper looked at how MOOCS and micro-credentials can be implemented in post-secondary education.
137	Keniry	2020		The study presented an opportunity to help previously disadvantaged youth to equip themselves with necessary skills. The study suggested ways of embedding micro-credentials into the curriculum.
138	Lane and Christensen	2015	Canada	This is a Canadian policy on micro-credentials. The policy identified the following: • importance of identifying necessary competencies • how to train different competencies, and • award credentials accordingly.
139	Laborde, Chadwick and Venant	2020	Not specified	The paper presented a user-centric and decentralized digital identity system that allows various individuals to benefit from the system in terms of competencies.
140	Young and Verhulst	2018	USA	The case study presented the use of blockchain to implement stackable micro-credentials.
141	Payne, Reardon, Janysek, Lorenz and Lampi		USA	The study noted the link between credentials status and class performance. Teachers with credentials tend to have more participants. The study further recommended the use of micro-credentials to support adult education.

No.	Author	Year	Country	Summary of paper and key findings
142	McElnay, McGoldrick, Beamish, Hoo, Gokani and Harries	2016	UK	The study was conducted as a consultative process on the implementation of credentialing in postgraduate medical practice. The study recommended the following: • funding models for micro-credentials, and that • the accreditation process should be on the alert for overlapping skills or competencies that are already accredited
143	Glover and Malone	2014	UK	This paper proposed a model for life-wide and life-long learning awards. The model uses an outsourced assessment model to reduce the workload on students and staff. The model uses open badges and verifiable digital credentials.
144	Gammon	2016	USA	The study was conducted to find out how credentials may support dropout learners in rural areas.
145	Fulton	2019	Ireland	This was a pilot study conducted on the implementation of badges among undergraduate students. The study indicated the importance of badging practices and strategies that enhance learning through assessment.
146	Facey-Shaw, Specht and Bartley-Bryan	2018	Not specified	The study aimed to find a link between digital badges and motivation. The study found that badges were positively received and a source of motivation. Students requested physical badges as well to validate achievements and competitive badges for motivation.

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