VICTORIA UNIVERSITY
MELBOURNE AUSTRALIA

A systematic literature review of micro-credentials in higher education: a non-zero-sum game

This is the Accepted version of the following publication

A Systematic Literature Review of Micro-credentials in Higher Education: A Non-Zero-Sum Game

This systematic review examines academic literature published between 2012 and 2022 on micro-credential research and practices in higher education. A deductive analysis of empirical evidence from the 29 included articles offers insights into awareness, benefits, challenges, effectiveness, and factors influencing effectiveness of micro-credentials in the sector. The results suggest that there are potential benefits for including micro-credentials in higher education. The findings also highlight that micro-credentials are not a micro task for students to complete or for higher education providers to successfully implement. Micro-credentials in higher education, however, are still at the early stage of development, and further research is required to evaluate their viability and effectiveness in the long term. The review carries implications for micro-credential research and practices.

Keywords: literature review, systematic review, micro-credentials, higher education, education innovation

Introduction

Existing literature reinforces that the 21st century is characterised by tremendous opportunities and risks, complex challenges, and intense competition, with jobs organised flexibly in time and space (Harteis, 2018). Employers increasingly seek job-ready employees who can utilise and exhibit their employability skills immediately upon recruitment (Gauthier, 2020). Employees' perspectives on careers have also changed significantly; no longer bound by loyalty, trust, and stability, employees increasingly desire adaptability, independence, and identity (Clarke, 2013). While employers have gained greater flexibility by offering contract, casual, and part-time jobs, employees are experiencing increasing pressure to be more independent and desirable in the labour market (Bodewig et al., 2014; Tran, 2019).

An undergraduate degree has not been considered "a passport into graduate employment" for some time (Harvey, 2000, p. 7). As conceptualised in the graduate capital model, graduate employability is represented by five forms of capital: (i) human – knowledge and skills, (ii) social – network and human relationships, (iii) cultural – cultural synergy and alignment, (iv) identity – self-concept and personal narratives, and (v) psychological – resilience and career adaptability. These capitals are acquired over time through formal and informal experiences (Tomlinson, 2017). Although employability implies a personal responsibility focus from the employee, it is increasingly acknowledged as a collective mission and achievement goal of universities, industry, government, and community (Oria, 2012; Tran, 2018). As a group of stakeholders, employees and universities bear the heaviest burden of responsibility for skills shortages (Tran, 2018). Furthermore, as players of the game of employability, both employees and universities must make decisions to allocate resources strategically to prepare and remain competitive in the highly demanding labour/training market.

Previous research revealed that employees seek ways to shorten the transition time from education to work and vice versa, and to quickly adapt to changing industry demands and unexpected events around the world (Gauthier, 2020). There is also growing expectation from employees for training programmes that incorporate industry-aligned curriculum, work-integrated learning approaches, and quality verification by employers (Gallagher, 2018). In response, higher education institutions across the globe have begun to offer micro-credentials, also known as digital badges, certifications, massive open online courses (MOOCs), and short courses (Universities Australia, 2021). Universities may also see the benefit of exploring the provision of micro-credentials as a potential vehicle to increase student enrolments and load in the face of a near saturated domestic market and slowing demand for traditional qualifications in demand-driven systems. For example, in Australia,

growth in government supported enrolment in undergraduate degrees has slowed to levels below population growth (Universities Australia, 2020).

Although there is some commonality between the definitions used in different countries, to date, there is no internationally agreed definition of micro-credentials (Department of Education Skills and Employment, 2021). In line with the suggestion of Oliver (2019), which is the basis for the definition in the Australian National Micro-credentials Framework (Department of Education Skills and Employment, 2021), in this review, a micro-credential is defined as "a certification of assessed learning that is additional, alternative, complementary to or a component part of a formal qualification" (Oliver, 2019, p. 19).

In the research literature, the inclusion of micro-credentials in higher education has been debated. Advocates state that micro-credentials increase the university responsiveness to labour markets, as well as contribute to social inclusion and education accessibility. Perceived advantages of micro-credentials as compared with traditional higher education courses include greater flexibility and affordability, greater likelihood of completion, and better accessibility for learners from disadvantaged backgrounds (Gallagher, 2018; Oliver, 2019, 2021). Critics of micro-credentials in higher education argue they are 'gig qualifications for the gig economy', which place more employment burden on individuals and accelerate the privatisation of education (Wheelahan & Moodie, 2021b).

Although attention to micro-credentials has escalated, a search of the literature, with key word "micro-credential", reveals a limited number of empirical investigations into micro-credentials in higher education contexts. Meanwhile, students and employers are doubtful about how universities implement micro-credentials, how effective micro-credentials are, and what benefits they could bring to students (Oliver, 2019). This systematic literature review synthesizes the literature on micro-credential research and practices in higher education. In

addition to the umbrella term, "micro-credentials", this review also examines the following types of micro-credentials: digital badges, certifications, massive open online courses (MOOCs), and short courses. Findings will be beneficial for researchers, learners, education providers, and employers who are interested in micro-credential research and practices, as well as program design, development, and implementation.

Micro-credentials and Macro-credentials

Credentials can be categorised as micro-credentials or macro-credentials. Macro-credentials "include degrees, diplomas, certificates, and licences, awarded by accredited, recognised or regulated educational organisations. They indicate learning achievement of a broad body of knowledge, transferable skills or technical proficiency and may take a number of years to complete." (Oliver, 2021, p. 16). Micro-credentials, which are defined as outlined above, refer to smaller, shorter, and more focused units of study (Oliver, 2021).

According to Olcott Jr (2021), micro-credentials in higher education are not a new phenomenon because the underlying principles – which include competency-based approach, short learning experiences, and established standard of quality, have been applied in the sector for some time. However, a renewed interest in micro-credentials within higher education is more recent.

In this review, four types of micro-credentials were included:

1. Digital badge: an online display that recognises and validates the achievement of skills and competencies through explicit evidence (Alt, 2021)

2. Industry/professional certification: an award from an industry or an occupational association to acknowledge the applicant's knowledge, skills, and ability to perform a specific job, obtained through an examination process (Boo & Kim, 2020)

3. Massive open online course (MOOC): an online open-access, large-scale class taught by university faculties, framed in a time period in order to address specific learning objectives (Phan et al., 2016)

4. Short course: a study programme taught by university faculties in a short period of time to achieve specific learning objectives (Atkinson, 2021)

Research Methodology

This systematic review examines empirical literature pertaining to the characteristics, awareness, benefits, challenges, and factors influencing the effectiveness of micro-credentials in higher education. It followed Petticrew and Roberts (2008)'s guidance on conducting systematic reviews in the social sciences. Systematic reviews identify, assess, and synthesize all relevant studies to answer research question(s) by "adher[ing] closely to a set of scientific methods that explicitly aim to limit systematic error (bias)" (p. 9). As "a survey of the literature" (p. 10), a systematic review is a useful means to address research questions of which the answers are uncertain (Petticrew & Roberts, 2008). This is the case for micro-credentials in higher education, as the literature details that relevant stakeholders still harbour doubts over the implementation, effectiveness, and benefits of micro-credentials (Oliver, 2019).

The review includes five key steps: (Step 1) defining the research question, (Step 2) deciding on the review's inclusion/exclusion criteria, (Step 3) conducting the literature search, (Step 4) appraising the studies, and (Step 5) undertaking data extraction, synthesis and analysis (Petticrew & Roberts, 2008). Specifically, Step 3 and 4 – literature search, and study appraisal – go through a four-phase procedure: (i) literature identification, (ii) screening, (iii) eligibility assessment, and (iv) quality assessment (Alexander, 2020; Lee, 2021; Xiao & Watson, 2019).

Step 1: Research Question

The review addresses the key question *"What does the literature detail in relation to characteristics, awareness, benefits, challenges, and factors influencing the effectiveness of micro-credentials in higher education?"*. This review aims to examine:

- (RA1) Key characteristics of micro-credentials in higher education studies, including year and source of publication, research purposes, research context, research design, and research participants.
- (RA2) Awareness, benefits, and challenges of micro-credentials in higher education.
- (RA3) Effectiveness of micro-credentials in higher education, and factors influencing their effectiveness.

Step 2: Selection Criteria

The following inclusion and exclusion criteria were established.

Inclusion criteria:

- Empirical, peer-reviewed, scholarly journal articles reporting data derived from actual observation or experimentation
- Articles exploring micro-credential practices and learning experiences in higher education settings from the perspectives of related stakeholders such as learners, employers, and higher education providers. These include:
  - awareness, which we define as knowledge or perception of micro-credentials (e.g., interest to study a micro-credential or intentions to develop micro-credentials);
  - benefits, which we define as advantages gained from micro-credentials (e.g., improved professional competencies or development of new teaching materials);

- challenges, which we define as difficult problems occurring in the

  implementation of micro-credentials (e.g., students' limited prior knowledge

  and skills or keeping course materials relevant or up to date);

- effectiveness, which we define as meeting desired outcomes and student

  satisfaction (e.g., enjoyment of study or development of a constructive

  learning environment); and

- factors influencing effectiveness, which we define as influences on the

  capability of meeting desired outcomes when developing or delivering micro-

  credentials (e.g., course quality and design or provider reputation).
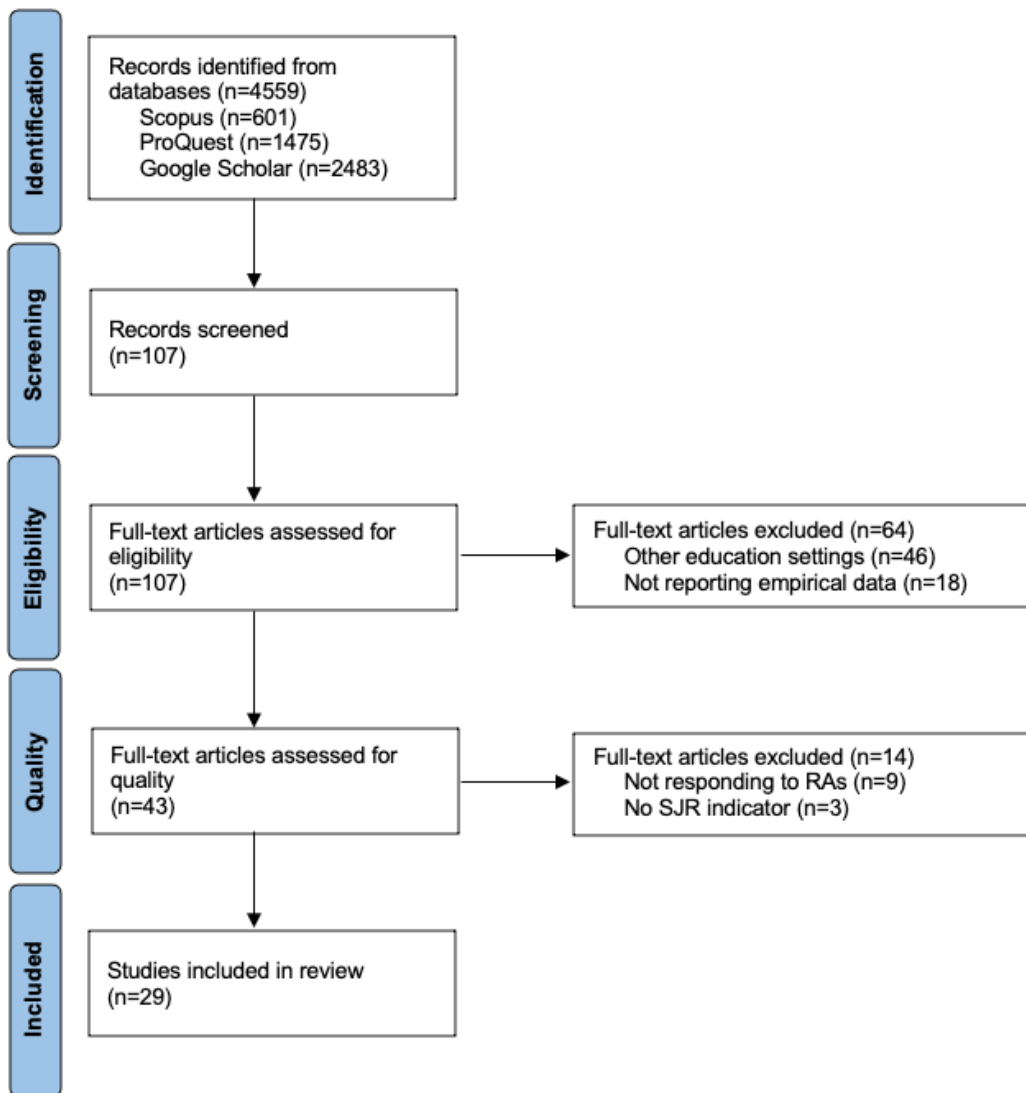
Exclusion criteria:

- Research work published in other forms such as book chapters, conference

  proceedings, theses, reports, magazines, or handbooks

- Full text articles that could not be retrieved

- Articles that are not available in English

Step 3 and 4: Literature Search and Study Appraisal

The literature search and identification were conducted by the first author. Two other

researchers (the second and third authors) were involved in the study appraisal process.

Specifically, the first and second researchers worked independently to assess the quality of

each article. Any differences between the two researchers' findings were discussed with the

third researcher to reach a consensus decision on article quality. Figure 1 presents the article

search and selection procedure. Details regarding the literature search and study appraisal are

provided below.

Figure 1. Article Search and Appraisal Process (Adapted from PRISMA Flow Diagram)

Identification

Records identified from databases (n=4559)
  Scopus (n=601)
  ProQuest (n=1475)
  Google Scholar (n=2483)

Screening

Records screened (n=107)

Eligibility

Full-text articles assessed for eligibility (n=107)

Full-text articles excluded (n=64)
  Other education settings (n=46)
  Not reporting empirical data (n=18)

Quality

Full-text articles assessed for quality (n=43)

Full-text articles excluded (n=14)
  Not responding to RAs (n=9)
  No SJR indicator (n=3)

Included

Studies included in review (n=29)

Literature Identification

The literature search was conducted from December 2021 to February 2022 using three popular databases: Scopus, Google Scholar, and ProQuest. Keywords used to search potential articles were: "micro-credentials" and "higher education", "microcredentials" and "higher education", "digital badges" and "higher education", "industry certifications" and "higher education", "professional certifications" and "higher education", "massive open online courses" and "higher education", "MOOCs" and "higher education", "short courses" and "higher education", and "short-term courses" and "higher education". Publication dates included were 2012 to 2022.

Screening

Exclusion criteria were integrated into the screening phase. Accordingly, only peer-reviewed scholarly journal articles which were written in English and which could be retrieved in full text were considered. The relevance of each search result was initially assessed by title. A total of 107 articles were identified in this step. Full text articles were also downloaded for further assessment.

Eligibility Assessment

Abstracts were carefully read and, when necessary, the methodology section of full text articles was reviewed to further assess whether the article met the inclusion criteria. The eligibility assessment excluded 46 articles which discussed micro-credentials in other education settings such as primary, secondary, vocational education, or in professional development. Of the 61 remaining articles, 18 review and provocation/argumentative research papers did not meet the inclusion criteria, resulting in 43 articles progressing to quality assessment.

Quality Assessment

In this study, full-text articles were skimmed to evaluate their ability to address research aims RA2 and RA3. Quality assessment eliminated nine articles that did not discuss micro-credential implementation. The SCImago Journal Rank (SJR) indicator and impact factor measuring the journal quality were also taken into consideration. From this, three articles published in journals that were not ranked in the SCImago Journal Rank were excluded. A total of 29 articles progressed to the next stage of full-text analysis (Table 1).

Table 1. Selected Article Details

ID	Article
A1	Ashcroft et al. (2021)
A2	Peacock et al. (2020)
A3	Alt (2021)
A4	Joseph et al. (2021)
A5	Foli et al. (2016)
A6	Govindarajoo et al. (2021)
A7	Newby and Cheng (2020)
A8	Humphrey Jr et al. (2021)
A9	Cowley et al. (2021)
A10	Deale and Schoffstall (2015)
A11	Laverie et al. (2020)
A12	Boo and Kim (2020)
A13	Jung and Lee (2018)
A14	Gilliat-Ray (2020)
A15	Tawfik et al. (2017)
A16	Al-Rahmi et al. (2021)
A17	Albelbisi and Yusop (2019)
A18	Shapiro et al. (2017)
A19	Anderson et al. (2020)
A20	Al-Atabi and DeBoer (2014)
A21	de Moura et al. (2021)
A22	Phan et al. (2016)
A23	Virani et al. (2020)
A24	Khalil and Ebner (2017)
A25	Hone and El Said (2016)
A26	Alraimi et al. (2015)
A27	Rieber (2017)
A28	Atkinson (2021)
A29	Dayton et al. (2018)

Step 5: Data Extraction, Synthesis, and Analysis

During the literature search and study appraisal process (Step 3 and 4), general information

on each article was recorded in an excel spreadsheet, including title, authors, publication

year, journal, impact factor, SJR indicator, publisher, education sector, research

methodology, research context, participants, and sample size. This information was used in

the discussion of the article selection and revealed general characteristics of the 29 selected

articles (as per research aim RA1).

 NVivo version 12 was used to support the researchers in organising, synthesizing,

analysing, managing, and querying data. In this step, the 29 selected articles were regarded as

29 cases, which were defined as "units of analysis" in NVivo (Bazeley & Jackson, 2013, p. 50). Each case was assigned attributes – the general characteristics identified in Step 3 and 4. A deductive thematic analysis was used to analyse the data (Creswell & Creswell, 2017). Each article was coded by identifying text segments that discussed: awareness, benefits, or challenges of micro-credentials in higher education (as per RA2); effectiveness, or factors influencing effectiveness of micro-credentials in higher education contexts (as per RA3) (Creswell & Creswell, 2017). This was followed by inductive analysis to group similar nodes (coded information) into the same categories, which resulted in sub-themes under the themes defined from the research aims RA2 and RA3.

Results

Research Aim 1: Key Characteristics of Micro-credential in Higher Education Studies

Year and Source of Publication

All selected articles were published from 2014 to 2021; none were published in 2012 or 2013. Interestingly, more than 50% of the articles were published in the two most recent years of the review (2020 and 2021), and over 30% in 2021 only. A majority of qualifying articles (52%) were obtained using the key words, 'massive open online courses' or 'MOOCs', followed by 'digital badges/badges' (21%) and 'professional certifications/industry certifications' (14%). The remaining key words -- 'micro-credentials/microcredentials' and 'short courses/short-term courses' yielded the smallest proportion of studies (7% each) (see Appendix 1).

Regarding the publication source, the largest proportion of articles were published by Elsevier (31%), followed by Taylor & Francis (21%), and Springer (14%). Journals included in this review have impact factors ranging from 0.26 to 8.53, and an SJR index from 0.17 to

3.03. As the journal names suggest, micro-credential in higher education studies have been conducted across a variety of fields, including Chemistry, Health, Marketing, Tourism-Hospitality, and Religion. Notably, six articles were published in Computers & Education – this journal has the highest impact factor (IF=8.53) and SJR index (SJR=3.03) of journals included in this review (see Appendix 2).

Research Purposes and Contexts

Around 40% of all selected articles explored micro-credential effectiveness and factors influencing effectiveness, and over one-third investigated micro-credential learning experiences. The remaining studies focused on the value of micro-credentials (13.81%), and educator perspectives regarding the acceptance and use of micro-credentials (10.33%) (see Appendix 3).

Online was the most common learning mode (55%), followed by face to face (34%), and blended (10%). Results also show that micro-credentials were implemented across many disciplines. Nearly half of all selected articles investigated the use of micro-credentials in the social sciences, and around one-fourth in STEM. Regarding location, the 29 studies reported micro-credential practices in 11 countries across four continents (with none in Oceania). At the continent level, the proportion of published articles in the Americas was 55%, nearly double that in Asia (21%), Europe (7 %), and Africa (3%) combined. At the country level, the USA was the research location for 14 of the 29 articles. This figure far outnumbered the second most represented country – Malaysia (n=3) (see Appendix 4).

Research Methodology and Participants

A quantitative methodology was the research approach of more than two-thirds of the qualifying articles. The remaining employed mixed-methods (14%), multi-methods (10 %), or qualitative approaches (7%). A variety of methods were used; survey was the predominant

method (86%). Course datasets, including information about learner profiles, logins, scores, and discussion posts were also frequently used in understanding micro-credential practices (24%) (see Appendix 5).

Students were participants in most studies. Almost 90% of the selected articles included student voices, with nearly 76% examining micro-credentials from the student perspective only. Educators participated in approximately 20% of the studies. Only one study (A1) included employers as participants, which suggests that the issue of employer perception of micro-credentials has been minimally explored (see Appendix 6)

Research Aim 2: Awareness, Benefits, and Challenges of Micro-credentials in Higher Education

Awareness

Of the 29 selected articles, only study (A1) investigated awareness of micro-credentials. Results of employer (n=124) and student surveys (n=1,016) revealed the low awareness of micro-credentials among research participants. Employers were more uncertain than students about micro-credential quality assurance, which institutions provide micro-credential offerings, and how micro-credentials demonstrate skill acquisition. The low level of micro-credential familiarity was reaffirmed by seven subsequent semi-structured interviews with students in the qualitative phase of this study, as the majority of interviewees stated that they had no or little understanding of micro-credentials.

Benefits

There were 14 articles examining benefits of micro-credentials in higher education. Most studies examined benefits for students (n=14), with fewer for education providers (n=3) or educators (n=3). Micro-credentials were found to provide students with a wide range of

benefits associated with job and study. The top two benefits identified were: (i) developing professional competencies (f=6) such as task mastery and professional technique, and (ii) strengthening knowledge and skills (f=5). Assessed by higher education providers as a beneficial teaching tool, micro-credentials offered providers opportunities to 'flip' the classroom, update teaching materials, and provide relevant supplements to student learning. Interestingly, educators who provided micro-credentials assessed themselves as more innovative, industry-aligned, and could create greater value for students than other educators who did not provide micro-credentials (see Appendix 7).

Challenges

Of the 29 selected articles, 11 explored challenges that arose in the implementation of micro-credentials. Difficulties reported by students included ill-designed micro-credentials, students' inadequate academic background. The most frequently reported challenge was course content, which was evaluated as 'poor', 'confusing', or 'lightweight' (f=4); followed by students' inadequate academic background – defined as students having no or little prior knowledge of the learning content (f=3), technology-related issues such as lack of skills to use the online platform or lack of internet access (f=3), and time constraints (f=3). Course fees and course instructional design were also identified as challenges. Developing and updating teaching resources were concerns for micro-credential providers, mostly due to the fast-changing nature of industry practices and educational technology. University faculties were concerned with finding solutions to student cheating on online learning flatforms (see Appendix 8).

***Research Aim 3: Effectiveness of Micro-credentials in Higher Education, and
Factors Influencing Their Effectiveness***

Effectiveness

There were 14 articles that contained clear measures of micro-credential effectiveness and
student satisfaction (see Appendix 9). Positive outcomes were found in 13 studies; one article
reported negative outcomes. Although areas for improvement were identified, both students
(such as A3, A4, A7, and A8) and educators (A9) were generally satisfied with micro-
credential implementation and learning outcomes. The most commonly mentioned positive
impacts of micro-credentials were a constructive learning environment (f=4), an enjoyable
way to achieve better learning performance (f=4), a high level of peer support (f=3), and a
beneficial teaching method (f=3). However, the implementation of micro-credentials resulted
in disappointment regarding significant learning, defined as learning that significantly
changes peoples' lives, mostly due to the short-term duration of the course (A28).

Factors Influencing Effectiveness

Over half of selected articles (n=16) investigated factors influencing the effectiveness of
micro-credentials (see Appendix 10). Course quality and design stood out as the most
frequently reported factor (n=11). Specifically, ease of use (f=4), usefulness (f=3), content
(f=2), and enjoyment (f=2) were what students reported most valuing with micro-credentials,
especially those implemented on online platforms. Factors relating to students were also
important (n=7), including their preferences and attitudes towards micro-credentials (f=4),
academic background (f=3), academic self-efficacy (f=1), and influence from other people's
attitudes and intention to complete micro-credentials (f=1). The decision of students to
continue studying micro-credentials also relied on provider reputation, level of educator
interaction with students, educators' understanding of micro-credentials, and social media.

All identified factors indicated the challenges facing higher education providers in developing meaningful micro-credentials and maintaining student learning interests.

Discussion

This systematic review aimed to provide an examination of empirical literature published between 2012 and 2022 on micro-credential research and practices in higher education. Specifically, deductive analysis of empirical evidence from the 29 selected articles provided insights into the awareness, benefits, challenges, and effectiveness of micro-credentials, and factors influencing effectiveness, in higher education. General characteristics of the selected studies were also identified, which has implications for future research in micro-credentials. The review highlighted three key findings: (i) micro-credentials in higher education are at the early stage of development, (ii) it appears that it is worth including micro-credentials in higher education, and (iii) despite the name, micro-credentials are no micro task for either students or higher education providers.

Micro-credentials' Early Stage of Development

Consistent with the finding of Liyanagunawardena et al. (2017), this systematic review reaffirmed that micro-credentials in higher education are still in the early stage of development. The search terms, "micro-credentials" or "microcredentials" yielded only two empirical studies (Ashcroft et al., 2021; Peacock et al., 2020), both published in the two most recent years of the current review (2020 and 2021). The majority of the selected articles were published after the start of Covid-19 (early 2020), and more than half were identified using the search terms, 'massive open online courses' or 'MOOCs'. This result corroborates the ideas of Wheelahan and Moodie (2021a), who highlighted the impact of the pandemic on the surge in micro-credentials, and in particular the hype about MOOCs. However, it appears that this hype has not fully connected to the potential higher education market, as this review

16

reveals the low awareness of micro-credentials among both students and employers. At the higher education provider level, both increasing interest in and intention to implement micro-credentials have been reported globally (Selvaratnam & Sankey, 2021).

At the policy level, micro-credentials have attracted attention from governments and international organisations. For example, the inclusion of micro-credentials in national qualification frameworks has been completed in New Zealand and is being progressed in Europe (European Commission, 2020; Wheelahan & Moodie, 2021b). In Australia, the national micro-credentials framework for defining micro-credentials across higher education, vocational education, and industry has been recently released (Department of Education Skills and Employment, 2021). UNESCO is working on micro-credential recognition and portability at world levels, including an effort to propose a globally agreed definition of micro-credentials (Oliver, 2021).

Although substantial work remains to popularise this learning approach among students and employers, the policy and implementation efforts at both international and national levels, in partnership with the post COVID-19 trend of increasing micro-credential research, indicates potential for continued development of micro-credentials in higher education.

A 'Non-Zero-Sum Game'

A second key finding from this review is evidence largely supportive of including micro-credentials in higher education. This finding is in contrast to the suggestions of Moodie and Wheelahan (2020), who proposed that currently micro-credentials in higher education are "zombie skills sets" (p. 12) aiming to facilitate gig work. Moodie and Wheelahan (2020) and Wheelahan and Moodie (2021b) advocated for qualifications that (i) have value in society and the labour market, (ii) prepare students for a career and citizenship, and (iii) engage with

17

theoretical knowledge to support students' participating in debates in society and in their field of practice.

Results of this review revealed that micro-credentials provided students with a wide range of benefits associated with study and career progression that align with the Tomlinson (2017)'s model regarding the development of different forms of employability capitals. These were evidence within the literature relative to human (Alt, 2021; Newby & Cheng, 2020), social (Anderson et al., 2020; Gilliat-Ray, 2020), cultural (Dayton et al., 2018; Laverie et al., 2020), identity (Cowley et al., 2021; Humphrey Jr et al., 2021), and psychological capital (Boo & Kim, 2020; Laverie et al., 2020).

The most common reported job-related benefits of micro-credentials (see Appendix 7) included: (i) developing professional competencies (e.g., Anderson et al., 2020; Cowley et al., 2021), (ii) preparing for job search and career exploration (e.g., Boo & Kim, 2020; Dayton et al., 2018), (iii) building a professional network (Deale & Schoffstall, 2015; Gilliat-Ray, 2020), and (iv) understanding industry practices (e.g., Dayton et al., 2018; Humphrey Jr et al., 2021). Key values of micro-credentials for student learning experiences (see Appendix 7 and 9) were: (i) constructive learning environments with more formative feedback (e.g., Laverie et al., 2020; Newby & Cheng, 2020), (ii) scaffolds to enhance knowledge and skills (e.g., Alt, 2021; Newby & Cheng, 2020), (iii) high level of peer support (e.g., Anderson et al., 2020; Gilliat-Ray, 2020), and (iv) useful, narrowly-focused assessment tools (Alt, 2021; Humphrey Jr et al., 2021). Despite their short duration, micro-credentials were generally assessed as valuable to deep learners who pursued mastery learning goals (Alt, 2021; Laverie et al., 2020). The major limitation of micro-credentials identified from this review was the contribution of micro-credentials to significant learning – learning that helps students increase their ability to live life fully and meaningfully (Atkinson, 2021).

In line with the findings of Rosenbaum et al. (2010), this paper argues that there are no one-size-fits-all pathways from higher education to desirable careers and working lives. One U.S. study states: "[c]olleges have much more to offer than just four-year degrees" (Rosenbaum et al., 2010, p. 3), and micro-credentials are one of those potential offers. As discussed above, micro-credentials in higher education have just entered the early stage of development. It is too soon to dismiss the inclusion of micro-credentials in the sector, just as it is also too soon to confidently state that they should definitely be included.

Micro-credentials in higher education are not a zero-sum game. Micro-credentials' gain is not macro-credentials' loss; each potentially complements and strengthens the other. The review results identified the benefits of micro-credentials for key university stakeholders, including students, higher education institutions, educators, and employers (see Appendix 7). As a component part of a macro qualification, micro-credentials have the potential to create more motivation for students to attend lectures (Joseph et al., 2021), improve class involvement and interaction (de Moura et al., 2021; Gilliat-Ray, 2020), and help students achieve better learning performance (e.g., Alt, 2021; Boo & Kim, 2020). For higher education providers and educators, micro-credentials can (i) improve pedagogic process (Cowley et al., 2021; de Moura et al., 2021; Laverie et al., 2020), (ii) optimise educational time and costs (de Moura et al., 2021), (iii) enhance teaching performance (Cowley et al., 2021; Deale & Schoffstall, 2015), and (iv) create stronger connections to industry (Dayton et al., 2018; Deale & Schoffstall, 2015). The finding that micro-credentials have been implemented across many fields of study and in different learning modes around the world (see Appendix 4) presents evidence for the potential of micro-credentials in the higher education sector.

No Micro Task for Students or Higher Education Providers

As compared with traditional higher education courses, micro-credentials offer greater flexibility and affordability for students and better accessibility for learners from disadvantaged backgrounds (Gallagher, 2018; Oliver, 2019, 2021). These advantages, however, accompany challenges relating to students' inadequate academic background (Deale & Schoffstall, 2015; Phan et al., 2016; Shapiro et al., 2017), technology issues when micro-credentials were implemented on online flatforms (Albelbisi & Yusop, 2019; Cowley et al., 2021; Shapiro et al., 2017), course fees (Deale & Schoffstall, 2015; Shapiro et al., 2017), and time (Atkinson, 2021; Rieber, 2017; Shapiro et al., 2017). Many micro-credential students are mature learners still engaged in the workforce (Oliver, 2021) who may have other priorities in life. Micro-credentials, therefore, may be most appropriate for self-regulated, autonomous, and active learners (Gish-Lieberman et al., 2021).

This review also identified that low quality course design, content, and instructions were the most frequently reported challenge facing students when studying micro-credentials (e.g., Cowley et al., 2021; Gilliat-Ray, 2020). This finding mirrored the difficulties that higher education providers encountered when developing and implementing micro-credentials. Whereas provider reputation is one factor influencing the effectiveness of micro-credentials and students' intention to continue studying (Alraimi et al., 2015; Ashcroft et al., 2021; Cowley et al., 2021), university reputation alone cannot secure students' micro-credential interests and retention. Effectiveness of micro-credentials also relied on factors relating to course quality and design (e.g., Al-Rahmi et al., 2021; Albelbisi & Yusop, 2019), students (e.g., de Moura et al., 2021; Shapiro et al., 2017), educators (Jung & Lee, 2018; Peacock et al., 2020), and social media (e.g., Anderson et al., 2020; Virani et al., 2020).

Implications for Future Research

This systematic review carries several implications for future research. As discussed, micro-credentials are at the early stage of development. Further studies into the implementation and outcomes of micro-credentials are required, especially those examining the value and benefits of micro-credentials for learners in the long term. In addition, the majority of the selected studies investigated micro-credentials from student perspectives, while perceptions of other micro-credential stakeholders have been minimally explored. The voices of university leaders, lecturers, and employers should be included to provide further insights into micro-credential practices in higher education. In this review, only one article examined the awareness of micro-credentials – among students and employers. Awareness is an important issue for future micro-credential research. If students and employers are unaware of micro-credentials, this obviously limits their potential. In terms of research methodology, quantitative studies with the use of surveys were predominant. Therefore, the application of other approaches such as mixed-methods and qualitative could be considered in future investigations.

Limitations

Limitations of this review include the use of only three databases, the exclusion of articles that were not written in English, and the omission of articles published prior to 2012. There could, therefore, be relevant studies that have been overlooked due to the search strategy applied in the present study. Moreover, only four types of micro-credentials (digital badges, certifications, massive open online courses, and short courses), in addition to the umbrella term, micro-credentials, were included in this review. This restriction may have resulted in some types of micro-credentials, such as micromasters or nanodegrees, being excluded from the review.

Conclusion

This systematic literature review provides insights into micro-credentials research and practices in higher education. The review results revealed the potential value of micro-credentials in higher education, given the reported benefits for students, universities, and educators. Micro-credentials in higher education, however, are at the early stage of development, as evidenced by the international and national efforts on framing micro-credentials policies, and the increased interest and intention to implement micro-credentials among universities around the world. Although the findings indicated the potential for development in the sector, this review also underscored challenges associated with the implementation of micro-credentials. Despite the name, micro-credentials are no micro task for students to complete or for higher education providers to offer meaningful learning experiences for students. More importantly, the task ahead for governments and universities around the world is to build and raise the awareness of micro-credentials among the potential higher education market, including students and employers. As an education innovation, micro-credentials represent a promising venture for students and higher education providers. Time, efforts to implement, and future research are needed to further assess the viability and effectiveness of micro-credentials in higher education, especially in the long term.

References

Al-Atabi, M., & DeBoer, J. (2014). Teaching entrepreneurship using massive open online course (MOOC). *Technovation*, *34*(4), 261–264. https://doi.org/10.1016/j.technovation.2014.01.006

Al-Rahmi, W. M., Yahaya, N., Alamri, M. M., Alyoussef, I. Y., Al-Rahmi, A. M., & Kamin, Y. B. (2021). Integrating innovation diffusion theory with technology acceptance model: Supporting students' attitude towards using a massive open online courses (MOOCs) systems. *Interactive Learning Environments*, *29*(8), 1380–1392. https://doi.org/10.1080/10494820.2019.1629599

Albelbisi, N. A., & Yusop, F. D. (2019). Factors influencing learners' self–regulated learning skills in a massive open online course (MOOC) environment. *Turkish Online Journal of Distance Education*, *20*(3), 1–16. https://doi.org/10.17718/tojde.598191

Alexander, P. A. (2020). Methodological guidance paper: The art and science of quality systematic reviews. *Review of Educational Research*, *90*(1), 6-23.

Alraimi, K. M., Zo, H., & Ciganek, A. P. (2015). Understanding the MOOCs continuance: The role of openness and reputation. *Computers & Education*, *80*, 28–38. https://doi.org/10.1016/j.compedu.2014.08.006

Alt, D. (2021). Who benefits from digital badges? Motivational precursors of digital badge usages in higher education. *Current Psychology*, 1–12. https://doi.org/10.1007/s12144-021-02002-0

Anderson, V., Gifford, J., & Wildman, J. (2020). An evaluation of social learning and learner outcomes in a massive open online course (MOOC): a healthcare sector case study. *Human Resource Development International*, *23*(3), 208–237. https://doi.org/10.1080/13678868.2020.1721982

Ashcroft, K., Etmanski, B., Fannon, A.-M., & Pretti, T. J. (2021). Microcredentials and Work-Integrated Learning. *International Journal of Work-Integrated Learning*, *22*(3), 423–432.

Atkinson, C. L. (2021). Significant learning and public administration education: The impact of short-term courses. *Teaching Public Administration*, *39*(2), 192–209. https://doi.org/10.1177/0144739420977902

Bazeley, P., & Jackson, K. (2013). *Qualitative data analysis with NVivo*. Sage Publications

Bodewig, C., Badiani-Magnusson, R., Macdonald, K., Newhouse, D., & Rutkowski, J. (2014). *Skilling up Vietnam: Preparing the workforce for a modern market economy*. World Bank. https://doi.org/10.1596/978-1-4648-0231-7

Boo, S., & Kim, S.-H. (2020). The relationship between hospitality industry certification and course performance across multiple semesters. *Journal of Hospitality & Tourism Education*, *32*(2), 112–123. https://doi.org/10.1080/10963758.2019.1654893

Clarke, M. (2013). The organizational career: Not dead but in need of redefinition. *The International Journal of Human Resource Management*, *24*(4), 684-703. https://doi.org/10.1080/09585192.2012.697475

Cowley, S., Humphrey Jr, W., & Muñoz, C. (2021). Industry Certifications in Digital Marketing and Media Education: An Examination of Perceptions and Use Among Educators. *Journal of Marketing Education*, *43*(2), 189–203. https://doi.org/10.1177/0273475320948570

Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). Sage Publications.

Dayton, K. G., Koster, K., Prenkert, J. D., & Ridlon, R. (2018). Short-term global business immersion courses: Short-term program, long-term effects? *Business Horizons*, *61*(6), 903–911. https://doi.org/10.1016/j.bushor.2018.06.003

de Moura, V. F., de Souza, C. A., & Viana, A. B. N. (2021). The use of Massive Open Online Courses (MOOCs) in blended learning courses and the functional value perceived by students. *Computers & Education*, *161*, 104077. https://doi.org/10.1016/j.compedu.2020.104077

Deale, C. S., & Schoffstall, D. (2015). Hospitality and tourism education and industry certifications. *Journal of Hospitality & Tourism Education*, *27*(3), 112–119. https://doi.org/10.1080/10963758.2015.1064319

Department of Education Skills and Employment. (2021). *National Microcredentials Framework*. https://www.dese.gov.au/higher-education-publications/resources/national-microcredentials-framework?utm_source=sendgrid.com&utm_medium=email&utm_campaign=website

European Commission. (2020). *A European approach to micro-credentials*. https://education.ec.europa.eu/sites/default/files/document-library-docs/european-approach-micro-credentials-higher-education-consultation-group-output-final-report.pdf

Foli, K. J., Karagory, P., & Kirby, K. (2016). An exploratory study of undergraduate nursing students' perceptions of digital badges. *Journal of Nursing Education*, *55*(11), 640–644. https://doi.org/10.3928/01484834-20161011-06

Gallagher, S. R. (2018). *Educational credentials come of age: A survey on the use and value of educational credentials in hiring*. https://cps.northeastern.edu/wp-content/uploads/2021/03/Educational_Credentials_Come_of_Age_2018.pdf

Gauthier, T. (2020). The value of microcredentials: The employer's perspective. *The Journal of Competency-Based Education*, *5*(2), 1–6. https://doi.org/10.1002/cbe2.1209

Gilliat-Ray, S. (2020). Learning about Islam and Muslims online: Reflections on the design and delivery of a massive open online course (MOOC) 2014–2019. *Teaching Theology & Religion*, *23*(4), 252–264. https://doi.org/10.1111/teth.12568

Gish-Lieberman, J. J., Tawfik, A., & Gatewood, J. (2021). Micro-Credentials and Badges in Education: a Historical Overview. *TechTrends*, *65*(1), 5–7. https://doi.org/10.1007/s11528-020-00567-4

Govindarajoo, G., Lee, J. Y., & Emenike, M. E. (2021). Proof of Concept for a Thin-Layer Chromatography Digital Badge Assignment Within a Laboratory Practical Exam for a Nonchemistry Majors' Organic Chemistry Lab. *Journal of Chemical Education*, *98*(9), 2775–2785. https://doi.org/10.1021/acs.jchemed.1c00598

Harteis, C. (2018). Machines, change and work: An educational view on the digitalization of work. In C. Harteis (Ed.), *The impact of digitalization in the workplace* (pp. 1-10). Springer https://doi.org/10.1007/978-3-319-63257-5

Harvey, L. (2000). New realities: The relationship between higher education and employment. *Tertiary education and management*, *6*(1), 3-17. https://doi.org/10.1023/A:1009685205201

Hone, K. S., & El Said, G. R. (2016). Exploring the factors affecting MOOC retention: A survey study. *Computers & Education*, *98*, 157–168. https://doi.org/10.1016/j.compedu.2016.03.016

Humphrey Jr, W., Laverie, D., & Muñoz, C. (2021). The use and value of badges: Leveraging salesforce trailhead badges for marketing technology education. *Journal of Marketing Education*, *43*(1), 25–42. https://doi.org/10.1177/0273475320912319

Joseph, M. A., Natarajan, J., Buckingham, J., & Al Noumani, M. (2021). Using digital badges to enhance nursing students' attendance and motivation. *Nurse Education in Practice*, *52*, 103033. https://doi.org/10.1016/j.nepr.2021.103033

Jung, Y., & Lee, J. (2018). Learning engagement and persistence in massive open online courses (MOOCS). *Computers & Education*, *122*, 9–22. https://doi.org/10.1016/j.compedu.2018.02.013

Khalil, M., & Ebner, M. (2017). Clustering patterns of engagement in Massive Open Online Courses (MOOCs): the use of learning analytics to reveal student categories. *Journal of Computing in Higher Education*, *29*(1), 114–132. https://doi.org/10.1007/s12528-016-9126-9

Laverie, D., Humphrey, W., Manis, K. T., & Freberg, K. (2020). The digital era has changed marketing: A guide to using industry certifications and exploration of student perceptions of effectiveness. *Marketing Education Review*, *30*(1), 57–80. https://doi.org/10.1080/10528008.2020.1716806

Lee, Y.-M. (2021). Mobile microlearning: a systematic literature review and its implications. *Interactive Learning Environments*, 1–16. https://doi.org/10.1080/10494820.2021.1977964

Liyanagunawardena, T. R., Scalzavara, S., & Williams, S. A. (2017). Open Badges: A Systematic Review of Peer-Reviewed Published Literature (2011-2015). *European Journal of Open, Distance and E-learning*, *20*(2), 1–16. https://doi.org/10.1515/eurodl-2017-0013

Moodie, G., & Wheelahan, L. (2020). Micro credentials: Zombie skills sets resurrected as micro credentials. *Australian TAFE Teacher*, *54*(2), 12–15.

Newby, T. J., & Cheng, Z. (2020). Instructional digital badges: Effective learning tools. *Educational Technology Research and Development*, *68*(3), 1053–1067. https://doi.org/10.1007/s11423-019-09719-7

Olcott Jr, D. (2021). Micro-Credentials: A Catalyst for Strategic Reset and Change in US Higher Education. *American Journal of Distance Education*, 1–17. https://doi.org/10.1080/08923647.2021.1997537

Oliver, B. (2019). *Making micro-credentials work for learners, employers and providers*. https://wordpress-ms.deakin.edu.au/dteach/wp-content/uploads/sites/103/2019/08/Making-micro-credentials-work-Oliver-Deakin-2019-full-report.pdf?_ga=2.87742744.1435129097.1637135585-1053681965.1636931971

Oliver, B. (2021). *A conversation starter: towards a common definition of micro-credentials*. https://www.edubrief.com.au/uploads/4/5/0/5/45053363/draft_unesco_report_microcredentials_13_sept_21.pdf

Oria, B. (2012). Enhancing higher education students' employability: A Spanish case study. *International Journal of Technology Management & Sustainable Development*, *11*(3), 217-230. https://doi.org/10.1386/tmsd.11.3.217_1

Peacock, R., Grevatt, H., Dworak, E., Marsh, L., & Doty, S. (2020). Developing and evaluating an asynchronous online library microcredential: a case study. *Reference Services Review*, *48*(4), 699–713. https://doi.org/10.1108/RSR-07-2020-0048

Petticrew, M., & Roberts, H. (2008). *Systematic reviews in the social sciences: A practical guide*. Blackwell Publishing.

Phan, T., McNeil, S. G., & Robin, B. R. (2016). Students' patterns of engagement and course performance in a Massive Open Online Course. *Computers & Education*, *95*, 36–44. https://doi.org/10.1016/j.compedu.2015.11.015

Rieber, L. P. (2017). Participation patterns in a massive open online course (MOOC) about statistics. *British Journal of Educational Technology*, *48*(6), 1295–1304. https://doi.org/10.1111/bjet.12504

Rosenbaum, J. E., Stephan, J. L., & Rosenbaum, J. E. (2010). Beyond One-Size-Fits-All College Dreams: Alternative Pathways to Desirable Careers. *American Educator*, *34*(3), 2–13.

Selvaratnam, R., & Sankey, M. (2021). The state of micro-credentials implementation and practice in Australasian higher education. *Open Praxis*, *13*(2), 228–238. https://doi.org/10.5944/openpraxis.13.2.130

Shapiro, H. B., Lee, C. H., Roth, N. E. W., Li, K., Çetinkaya-Rundel, M., & Canelas, D. A. (2017). Understanding the massive open online course (MOOC) student experience: An examination of attitudes, motivations, and barriers. *Computers & Education*, *110*, 35–50. https://doi.org/10.1016/j.compedu.2017.03.003

Tawfik, A. A., Reeves, T. D., Stich, A. E., Gill, A., Hong, C., McDade, J., . . . Giabbanelli, P. J. (2017). The nature and level of learner–learner interaction in a chemistry massive open online course (MOOC). *Journal of Computing in Higher Education*, *29*(3), 411–431. https://doi.org/10.1007/s12528-017-9135-3

Tomlinson, M. (2017). Forms of graduate capital and their relationship to graduate employability. *Education + Training*, *59*(4), 338-352.

Tran, L. H. N. (2018). Game of blames: Higher education stakeholders' perceptions of causes of Vietnamese graduates' skills gap. *International Journal of Educational Development*, *62*, 302-312. https://doi.org/10.1016/j.ijedudev.2018.07.005

Tran, L. H. N. (2019). *Building soft skills for employability: Challenges and practices in Vietnam*. Routledge.

Universities Australia. (2020). *2020 Higher education facts and figures*. https://www.universitiesaustralia.edu.au/wp-content/uploads/2020/11/200917-HE-Facts-and-Figures-2020.pdf

Universities Australia. (2021). *Guidance for portability of Australian Microcredentials*. https://www.universitiesaustralia.edu.au/wp-content/uploads/2021/09/210929-Guidance-for-portability-of-Australian-microcredentials-UA.pdf

Virani, S. R., Saini, J. R., & Sharma, S. (2020). Adoption of massive open online courses (MOOCs) for blended learning: the Indian educators' perspective. *Interactive Learning Environments*, 1–17. https://doi.org/10.1080/10494820.2020.1817760

Wheelahan, L., & Moodie, G. (2021a). Analysing micro-credentials in higher education: A Bernsteinian analysis. *Journal of Curriculum Studies*, *53*(2), 212–228. https://doi.org/10.1080/00220272.2021.1887358

Wheelahan, L., & Moodie, G. (2021b). Gig qualifications for the gig economy: micro-credentials and the 'hungry mile'. *Higher Education*, 1–17. https://doi.org/10.1007/s10734-021-00742-3

Xiao, Y., & Watson, M. (2019). Guidance on conducting a systematic literature review. *Journal of Planning Education and Research*, *39*(1), 93–112. https://doi.org/10.1177/0739456X17723971

Appendices

Appendix 1. Number of Articles by Year and Key Word

		f	%	Article ID
Year of publication	2021	9	31.03	A1, A3, A4, A6, A8, A9, A16, A21, A28
	2020	7	24.13	A2, A7, A11, A12, A14, A19, A23
	2019	1	3.45	A17
	2018	2	6.89	A13, A29
	2017	4	13.81	A15, A18, A24, A27
	2016	3	10.35	A5, A22, A25
	2015	2	6.89	A10, A26
	2014	1	3.45	A20
Key word	Micro-credentials Microcredentials	2	6.89	A1, A2
	Digital badges Badges	6	20.67	A3, A4, A5, A6, A7, A8
	Professional certifications Industry certifications	4	13.78	A9, A10, A11, A12
	Massive open online courses (MOOCs)	15	51.77	A13, A14, A15, A16, A17, A18, A19, A20, A21, A22, A23, A24, A25, A26, A27
	Short courses Short-term courses	2	6.89	A28, A29

f=frequency

Appendix 2. Number of Articles by Publisher and Journal

Publisher	Journal	IF	SJR	f	%	Article ID
American Chemistry Society (USA)	Journal of Chemical Education	2.97	0.50	1	3.45	A6
Anadolu University (Turkey)	Turkish Online Journal of Distance Education	1.24	0.37	1	3.45	A17
Elsevier (Netherlands)	Nurse Education in Practice	2.28	0.92	1	3.45	A4
	Computers & Education	8.53	3.03	6	20.69	A13, A18, A21, A22, A25, A26
	Technovation	6.66	2.30	1	3.45	A20
	Business Horizons	6.68	2.17	1	3.45	A29
Emerald (UK)	Reference Services Review	0.86	0.71	1	3.45	A2
Taylor & Francis (UK)	Journal of Hospitality & Tourism Education	2.11	0.52	2	6.89	A10, A12
	Marketing Education Review	1.65	0.59	1	3.45	A11
	Interactive Learning Environments	2.87	0.92	2	6.89	A16, A23
	Human Resource Development International	1.27	0.43	1	3.45	A19
Sage (USA)	Journal of Marketing Education	3.12	0.98	2	6.89	A8, A9
	Teaching Public Administration	1.13	0.27	1	3.45	A28
Slack Inc. (USA)	Journal of Nursing Education	1.72	0.70	1	3.45	A5
Springer (USA)	Current Psychology	4.29	0.50	1	3.45	A3
	Educational Technology Research and Development	3.56	1.35	1	3.45	A7
	Journal of Computing in Higher Education	2.62	1.28	2	6.89	A15, A24
Wiley (USA)	Teaching Theology & Religion	0.26	0.17	1	3.45	A14
	British Journal of Educational Technology	2.95	1.79	1	3.45	A27
IJWIL (NZ)	International Journal of Work-Integrated Learning (IJWIL)	1.82	0.58	1	3.45	A1

IF=impact factor, SJR=SCImago Journal Ranking, f=frequency

Appendix 3. Number of Articles by Research Purpose

General purpose	f	%	Article ID
To investigate micro-credential learning experiences	10	34.48	A3, A5, A6, A12, A15, A18, A19, A21, A22, A27
To investigate the effectiveness of micro-credentials	6	20.69	A2, A4, A7, A14, A28, A29
To investigate factors influencing micro-credential effectiveness/learning experiences	6	20.69	A13, A16, A17, A24, A25, A26
To investigate value of micro-credentials	4	13.81	A1, A8, A11, A20
To investigate educator perceptions and use of micro-credentials	3	10.33	A9, A10, A23

f=frequency

Appendix 4. Number of Articles by Research Context

	Context	f	%	Article ID
Learning mode	Face to face	10	34.48	A1, A3, A4, A6, A7, A9, A10, A11, A12, A29
	Online	16	55.18	A2, A5, A13, A14, A15, A16, A17, A18, A19, A20, A22, A24, A25, A26, A27, A28
	Blended	3	10.34	A8, A21, A23
Discipline	STEM	7	24.13	
	• Engineering	1	3.45	A1
	• Healthcare/Nursing	3	10.34	A4, A5, A19
	• Chemistry	2	6.89	A6, A15
	• IT	1	3.45	A25
	Social sciences	14	48.26	
	• Education	3	10.34	A3, A7, A22
	• Marketing (+Media)	3	10.34	A8, A9, A11
	• Tourism-Hospitality	2	6.89	A10, A12
	• Religion	1	3.45	A14
	• Entrepreneurship	1	3.45	A20
	• Statistics	1	3.45	A27
	• Administration	3	10.34	A21, A28, A29
	Mixed	8	27.61	A13, A16, A17, A18, A23, A24, A26
Country of study	The Americas	16	55.18	
	• Canada	1	3.45	A1
	• USA	14	48.28	A2, A5, A6, A7, A8, A9, A10, A11, A12, A18, A22, A27, A28, A29
	• Brazil	1	3.45	A21
	Europe	3	7.34	
	• UK	2	6.89	A14, A19
	• Austria	1	3.45	A24
	Asia	6	20.69	
	• Oman	1	3.45	A4
	• Malaysia	3	10.34	A16, A17, A20
	• Israel	1	3.45	A3
	• South Korea	1	3.45	A13
	• India	1	3.45	A23
	Africa	1	3.45	
	• Egypt	1	3.45	A25
	Global	2	6.89	A15, A26

f=frequency

Appendix 5. Number of Articles by Research Methodology

Approach	Methods	f	%	Article ID
Quantitative (n=20)	Survey	14	48.28	A3, A4, A5, A8, A9, A10, A13, A14, A16, A17, A20, A23, A25, A26
	Survey+course dataset	4	13.80	
	• Pre- and post-surveys+ assignment scores+course grades	1	3.45	A7
	• Pre- and post- surveys+logins+ assignments+discussion posts	1	3.45	A27
	• Post-survey+course grades	1	3.45	A22
	• Survey+videos+files+ posts+scores+logins	1	3.45	A24
	Course dataset	2	6.89	
	• Discussion posts	1	3.45	A15
	• Student profile forms+course records+course grades+course reports	1	3.45	A12
Qualitative (n=2)	Notes+reports	1	3.45	A29
	Semi-structured interviews	1	3.45	A28
Mixed-methods (n=4)	Survey+semi-structured interviews	2	6.89	A18, A21
	Survey+phone interviews	1	3.45	A19
	Survey+scores+final exam+pre- and post-perception	1	3.45	A6
Multi-methods (n=3)	Surveys+semi-structured interviews	1	3.45	A1
	Survey+reflections	2	6.89	A2, A11

f=frequency

Appendix 6. Number of Articles by Research Participants

Research participants	f	%	Article ID
Students	22	75.87	A2, A3, A4, A5, A6, A7, A8, A11, A12, A13, A14, A16, A17, A18(3,036), A19, A20, A22, A24, A25, A26, A27, A28
Students + Employers	1	3.45	A1
Students + Educators	3	10.34	A15, A21, A29
Educators	3	10.34	A9, A10, A23

f=frequency

Appendix 7. Benefits of Micro-credentials

Benefits		f	Article ID
For students (n=14)			
Job related (n=9)	Increasing commitment to the field	1	A10
	Enhancing confidence	4	A6, A10, A11, A29
	Obtaining higher salary	1	A10
	Understanding industry practices	3	A8, A11, A29
	Preparing for job search and career exploration	4	A10, A11, A12, A29
	Developing professional competencies	6	A6, A8, A9, A10, A11, A19
	Creating professional development opportunities	2	A10, A14
	Building professional network	3	A10, A14, A19
	Preparing for workplace environment	1	A11
Study-related (n=10)	Achieving better course performance	4	A3, A7, A12, A21
	Increasing class attendance	1	A4
	Strengthening knowledge and skills	5	A1, A6, A7, A10, A19
	Improving class involvement and interaction	2	A14, A21
For HE providers and educators (n=5)			
HE providers (n=3)	Improving pedagogical process	3	A9, A11, A21
	Optimising educational time and costs	1	A21
Educators (n=3)	Achieving better teaching performance	2	A9, A10
	Connecting to industry and profession	2	A10, A29

f=frequency

Appendix 8. Challenges of Micro-credentials

	Challenges	f	Article ID
Facing students (n=10)	Course quality and design	5	
	• Content	4	A9, A14, A15, A18
	• Instructional design	1	A2
	Course fees	2	A10, A18
	Inadequate academic background	3	A10, A18, A22
	Technology	3	A9, A17, A18
	Time	3	A18, A27, A28
Facing HE providers (n=2)	Resources	2	A9, A11
	Student cheating	1	A9

f=frequency

Appendix 9. Effectiveness of Micro-credentials

	Reported outcomes	f	Article ID
Effectiveness (n=13)	A useful, narrowly focused assessment tool	2	A3, A8
	Scaffolds to enhance knowledge and skills	2	A3, A7
	A motivator to attend the lectures	1	A4
	A constructive learning environment with more formative feedback	4	A7, A11, A18, A20
	A beneficial teaching method	3	A9, A11, A29
	An enjoyable way to achieve better learning performance	4	A5, A7, A11, A12
	A high level of peer support	3	A14, A19, A20
Ineffectiveness (n=1)	Limit significant learning	1	A28

f=frequency

Appendix 10. Factors Influencing Effectiveness of Micro-credentials

Factors	f	Article ID
Course quality and design	11	A1, A13, A16, A17, A19, A21, A23, A24, A25, A26, A27
• Content	2	A17, A25
• Ease of use	4	A13, A16, A17, A23
• Enjoyment	2	A16, A26
• Usefulness	3	A13, A16, A26
Students	7	A2, A13, A17, A18, A19, A21, A22
• Academic background	3	A2, A18, A22
• Academic self-efficacy	1	A13
• Preference and attitude	4	A17, A19, A21, A22
• Influence from other people	1	A19
Provider reputation	3	A1, A9, A26
Educator interaction & understanding of micro-credentials	3	A2, A13, A25
Social media	3	A14, A19, A23

f=frequency