



Education Sector

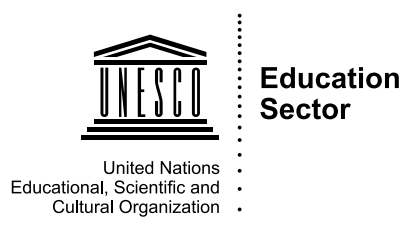
Digital Credentialing

Implications for the recognition of learning across borders



UNESCO Education Sector

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Acronyms and abbreviations

AACRAO	American Association of Collegiate Registrars and Admissions Officers	IGNOU	Indira Gandhi National Open University
AI	artificial intelligence	IJTEN	International Journal of Technology and Educational Marketing
AQRF	ASEAN Qualifications Reference Framework	ILO	International Labour Organization
BITKOM	Federal Association for Information Technology	IT	information technology
BMBF	Federal Ministry for Education and Research	ITU	International Telecommunication Union
CDE	common desktop environment	JISC	Joint Information Systems Community
CDSL	Central Depository Services Limited	JSON	JavaScript Object Notion
CDTL	Credential Transparency Description Language	LIU	Laureate International Universities
Cedefop	European Centre for the Development of Vocational Training	LRNG	Learning Redesigned for the Connected Age
CERI	Centre of Educational Research and Innovation	LRS	Learning Record Store
CHESICC	China Higher Education Student Information and Career Center	MENA	Middle East and North Africa
COL	Commonwealth of Learning	MIT	Massachusetts Institute of Technology
CRQF	Caribbean Regional Qualification Framework	MOE	Ministry of Education
CSCSE	Chinese Service Center for Scholarly Exchange	MOOC	massive open online courses
DCN	Digital Certificate Number	NLRD	National Learners' Records Database
DS	diploma supplement	NSC	National Student Clearinghouse
EAR	European Area of Recognition	OBI	open badge infrastructure
EC	European Commission	OECD	Organisation for Economic Co-operation and Development
ECTS	European Transfer and Accumulation System	OER	open education resources
ECVET	European Credit System for Vocational Education and Training	OLT	optical line termination
EDGE	Electronic Database for Global Education	PESC	Postsecondary Electronic Standards Council
EDI	electronic data interchange	PLAR	prior learning assessment and recognition
ENIC-NARIC	European Network of Information Centres – National Academic Recognition Information Centres	PQF	Pacific Qualifications Framework
EQF	European Qualifications Framework	RPL	recognition of prior learning
ESCO	European Skills, Competences, Qualifications, and Occupations	SADC	Southern African Development Community
ETF	European Training Foundation	SDG	Sustainable Development Goal
EU	European Union	SPOCs	small private online courses
GCE	Global Citizenship Education	SQDC	safety, quality, delivery and cost RQF Regulated Qualifications Framework
GDN	Groningen Declaration Network	SWAYAM	Study Webs of Active Learning for Young Aspiring Minds
HASTAC	Humanities, Arts, Science and Technology Alliance and Collaboratory	TAICEP	Association for International Credential Evaluation Professionals
HEA	Higher Education Academy	TQF	Teaching Qualify Framework
HEAR	Higher Education Achievement Record	TVET	technical and vocational education and training
HEDD	Higher Education Degree Datacheck	UNESCO	United Nations Educational Scientific and Cultural Organization
HEI	higher education institutions	UNISA	University of South Africa
ICT	information and communication technology	WRLs	world reference levels
IEEE	Institute of Electrical and Electronics Engineers		

Executive Summary

Digital technologies are creating new opportunities and challenges for skills development and recognition globally. Changes in modalities of access and learning methods, massification and internationalization, are taking place at an increasingly rapid pace. In this context, significant attention is being given to the impact of technology on jobs and demand for skills, and the risks of competition between robots and humans. Far less has been said about the opportunities that advances in digital technology will create for transforming education and training systems, including building new credentialing methods and systems that can capture, recognize and validate a broader range of learning outcomes in the era of lifelong learning.

There is increasing evidence that the use of digital technologies in education and training is supporting the development of learning materials and close monitoring of teaching and learning processes, changing pedagogies and forms of assessment and certification. Digital learning records and open data sources are complementing

traditional qualifications repositories, while challenging the conventional models of credential evaluation, as both for-profit and non-profit verification agencies come to the fore as important players. These changes trigger many questions about the trustworthiness of data, interoperability of systems, and most critically the ubiquity of the standards – both learning standards and technology standards – that govern the new and dynamic landscape. In this report, we consider these changes and offer a critical assessment of digital credentialing based on a review of the recent literature and a series of interviews with key actors. We argue for increased synergies between these developments and the quality assurance systems that have become closely associated with the implementation of a new generation of qualifications frameworks internationally. We offer an outline of the ecosystem of these digital credentials and show the convergence and divergence with traditional qualifications frameworks. We propose that world reference levels – now in development – are key to expediting recognition of skills and qualifications across borders.

Chapter 1. Introduction

1. Understanding and recognizing learning in digital economies and societies

In today's increasingly digitized economies and societies, accessing and understanding data about learning outcomes, skills and credentials is critical to achieving the 2030 Sustainable Agenda, including Sustainable Development Goal (SDG) 4, with its particular focus on quality and inclusive education, recognizing and offering lifelong learning opportunities for all. In this context, different stakeholders have different needs: education and training providers need learning data to build new programmes and learning pathways; employers need the data to understand where to find qualified workers; and learners and workers need data to discern which learning pathways are more likely to lead to career opportunities.

To date there has not been an efficient national or global system to collect, connect, search and compare up-to-date information about learning outcomes and credentials in a common language or format that can be universally understood and easily accessed. This lack of information and systems contributes to confusion, lack of trust and uninformed decision-making regarding the recognition of skills and qualifications within and across borders. It also leads to talent loss for economies and employers.

We urgently need a vision to reach a common international approach where all aspects of a person's learning are electronically documented, authenticated and can be accessed at any time and anywhere, shared and amended by the owner or by an authorized party.

2. Is there a problem with credentials as we know them today?

Increasingly referred to as 'macro-credentials' (Oliver, 2016a), this recognition of learning through the award of qualifications is steeply entrenched in the history of education and training globally. In recent years, notably since the 1990s,

qualifications frameworks have emerged as a new 'technology' that has attempted to improve the recognition of different forms of learning, the transferability of such recognition, and ultimately the mobility of individuals as global citizens (Keevy and Chakroun, 2015). At least three generations of qualifications frameworks have evolved since then, expanding with sectoral, national and also regional coverage, and with wide international acceptance, although there has also been some criticism regarding their relevance and impacts (Keevy and Chakroun, 2015).

Over the five years from 2013, a fourth generation of qualifications frameworks has started to emerge with a strong focus on credentials and the inclusion of twenty-first-century skills:

The recent developments in Canada and the USA, many of which are still taking place outside of the view of the public, provide some insights into the potential future of new fourth-generation qualifications frameworks. These frameworks are more inclusive of non-degree credentials, and also view learning domains in a similar but broader sense than has been the practice to date. The inclusion of 'citizenship, global participation and life' is an important feature. (Keevy and Chakroun, 2015, p. 136)

This generation of qualifications frameworks has embraced new developments, including the digitization of credentials (Lumina, 2016) and a closer alignment with credential evaluation methodologies (NUFFIC, 2012).

In higher education, UNESCO has engaged in a process of dynamic revisions of international recognition agreements. This has included the Lisbon Recognition Convention of 1997 in Europe, the Revised Convention on the Recognition of Studies, Certificates, Diplomas, Degrees and Other Academic Qualifications in Higher Education in African States of 2014, the Asia-Pacific Regional Convention on the Recognition of Qualifications in Higher Education 2011 and recent work on the Global Convention on Higher Education.¹ In different ways (for example the 2013 subsidiary text to the Lisbon Convention), these revised conventions recognize the value of developing qualifications frameworks and focusing on learning outcomes. They are also underpinned by strong calls for developing quality assurance arrangements and structures.

¹ See <https://en.unesco.org/themes/higher-education/recognition-qualifications> for an exhaustive list of conventions and the draft report on the Global Convention.

In the field of technical and vocational education and training (TVET), in 2012 UNESCO convened the Third International Congress on TVET in Shanghai to debate current trends and future drivers of the development of education and training. This global dialogue culminated in the Shanghai Consensus, which recommended, among other things, the development of international guidelines on quality assurance for the recognition of qualifications based on learning outcomes. This included the proposal that a set of world reference levels (WRLs) be considered to enable the international recognition of TVET qualifications. Looking beyond the reach of the existing qualifications frameworks, in 2013 UNESCO convened a working group of international experts to consider a set of WRLs. In essence, the WRLs were conceived as a translation device that would be able, in the future, to act as a neutral reference point for the recognition of learning across countries and regions (Chakroun and Ananiadou, 2017).² A range of reviews, analysis and developments have been conducted, including a publication on the use of level descriptors (Keevy and Chakroun, 2015, analysis of quality assurance arrangements in the Asia-Pacific region (Bateman and Coles, 2017), a draft proposal for WRLs (Chakroun and Daelman, 2015), referencing guidelines (Booker, 2016) and a review of level descriptors internationally (Hart, 2017).

The thinking on WRLs, as well as the work on developing qualifications systems and recognition of qualifications at national, regional and international levels, has increasingly been placed in the context of the Sustainable Development Agenda and Education 2030, with its focus on providing lifelong learning opportunities and recognizing learning outcomes (Chakroun, 2017). The process has also evolved to include qualifications beyond the TVET sector only.

It is also impacted by the growing digitization of credentials, also referred to as the advent of 'micro-credentials' (Ifenthaler et al., 2016). Recent developments and initiatives including the Groningen Declaration Network (GDN), the work of the Post-Secondary Electronic Standards Council (PESC), the Common Student System in Norway, and initiatives in other Nordic countries, point to the importance of UNESCO as a leading UN agency in education and training to map the landscape, identify key actors and chart future developments with partners. At the core of this process is the growing move towards digital credentialing, and specifically also micro-credentials, which has critical implications for the recognition of learning across borders.

This move is directly attributed to the length, cost and perceived low return on investment of traditional degrees (also referred to as macro-degrees) even when offered digitally, whereas smaller chunks of learning (also referred to as micro-credentials) provide greater flexibility, more so when offered digitally. Both macro-degrees and micro-credentials

have been offered for many years; what are new are the increasingly new and innovative ways in which both can be offered digitally. As noted by Oliver from Deakin University (pers. comm.), 'the idea is to put the first one or two units or subjects online at a much cheaper price: the learner can use that certificate as a standalone warrant of new skills, or as credit towards a degree, thus lowering cost and time'. The present report has been developed as an important step by UNESCO to grapple with these important issues.

3. How to represent learning outcomes beyond a qualification?

The digitization of the economy and society promises to bring dividends, spur innovation, generate efficiencies and improve quality of services to a wide range of sustainable development areas, including agriculture, health, infrastructure, environment and education (World Bank, 2016; OECD, 2016a; UNESCO, 2016). At the same time, digitization will be disruptive. It will raise a number of important policy challenges, including privacy, security, consumer protection, competition, taxation, new skills, cross-border and international delivery of education and training, and new forms of credentialing, to name but a few. It also runs the risk of worsening inequalities within and between countries. Countries unable to adjust swiftly to the digital economy will run the risk of falling behind.

For education and training, the stakes are high. The timeliness, or lack thereof, with which national or regional education and training systems respond to the opportunities and challenges will either result in these systems developing a system of virtuous interaction with the world of work, or contribute to widening the disconnect between the demand and supply of skills. This in turn will exacerbate skills gaps and unemployment in the future workforce and delay the speed of adjustment to the new context (that is, the digital economy and society) for the currently active workforce of 3 billion people (World Economic Forum, 2017).

Education and training systems will face both external and internal pressures. First, they will have to respond to the external demand for skills from the digital society and facilitate the transition to the new world of work. Second, like other sectors, education and training systems will have to embrace digital transformation in all its guises. The ultimate aim of such transformation must be to deliver successful skills development policy outcomes in the context of SDG 4: 'to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all, in particular

² See Chapter 4 for a more detailed account of the world reference levels process and related research.

to substantially increase the number of youth and adults with relevant skills for employment, decent jobs and entrepreneurship.³

Traditional degrees, or macro-credentials, have served important purposes over many years: particularly, to signal to employers that a graduate is employable. Increasingly there is dissatisfaction with qualifications (and the accompanying academic records) as a proxy for employability (Oliver, 2016b). Sessa goes as far as to say that ‘for employers, the transcript is dead’ (in PESC, 2017), basing this on the significant decrease PESC has experienced in demand for transcript standards from employers over the last few years. Alternatives are being mooted, and in some instances already implemented, such as a digital passport,⁴ e-qualification (Chen-Wilson and Argles, 2010), ‘3D CV’ (Oliver, 2017), and in our view, the seminal work by Bjornavold and Coles (2008) and Coles (2017) on ‘representation’⁵ which went largely unnoticed.

Oliver (2016a) provides the following reasons for employers’ apparent dissatisfaction with traditional credentials:⁶

- Conferring a degree based on time spent at the institution rather than demonstrated learning is no longer fit for purpose when qualifications frameworks and standards focus on outcomes.
- Some institutions provide ‘co-curricular’ certification of employability skills (examples include non-credit bearing awards that may not necessarily articulate with other university offerings), but these are of ‘lesser value’ than the official degree when the learners understand them to be ‘co’-curricular.
- If the learner undertakes a course primarily to qualify for a career (which is increasingly the case), and acquires an enormous debt in the process, it is unacceptable for them not subsequently to be able to obtain a job in that field.

Here it is important to note that alternatives to traditional credentials are all directly associated with digitization. It is as if digitization is making it possible to transcend the limits of traditional credentials, and address many of the concerns raised by employers. But it goes even further than this. Digital technologies are now driving change in education at a rate that is difficult to keep up with. As Lockley and colleagues pointed out, digital technologies provide important low-cost options which were previously not available:

There is a drive for future-focussed options while at the same time a push for lower cost alternatives for education. Digital credentials/badges provide a key to a

more visible and granular system that is extensible and adaptable to the changing marketplace, and as such may provide part of the answer. (Ifenthaler et al., 2016, p. 58)

Technological advances are impacting on ‘student participation and expectations, shifts in student demographics and rapid technological changes are prominent factors in new, more flexible study options and improved forms of recognition of the specific skills that students have acquired’ (James et al., 2017, pp. 2–3). Arguing that we are standing ‘on the brink of revolutionary change’, the authors of this quote concede that the higher education system is not ready to take on these changes. The same could be said in most developed and developing countries across the world. Of course, there are exceptions, and increasingly so.

This report attempts to look across the broad range of new developments and the learnings and challenges they bring to the recognition of learning across borders.

The overarching questions this report seeks to answer are:

- 1 To what extent are digital credentials (both micro and macro) achieving the various desired objectives associated with them, including recognizing lifelong learning?
- 2 How can digitization of micro and macro-credentials – including learning records and digital repositories – support the recognition of skills across borders?
- 3 What are the necessary conditions in which digital technologies can lead to better, fair and transparent recognition of skills and qualifications within and between countries?

Sub-questions include:

- a What are the major developments in digitizing learners’ records, credentials and certificates in education and training (including in companies)?
- b What are the technologies used and what are the issues and concerns related to security, compatibilities, interfaces and interoperability? What are the safety challenges involved and the existing and emerging solutions to protect individuals and prevent fraud?
- c What is the overall ecosystem? Who are the actors and what roles they play?

How might world reference levels of learning outcomes facilitate better solutions to the translation of learning outcomes across national borders? The report provides Member States and stakeholders active in the field of

3 <https://sustainabledevelopment.un.org>, accessed 22 June 2017.

4 <http://europass.cedefop.europa.eu>, accessed 8 June 2017.

5 Representation is defined as ‘ways of making learning achievements visible and understandable in a learning and working context, which is increasingly international, people are more mobile and communications increasingly sophisticated’.

6 www.assuringgraduatecapabilities.com/credential.html, accessed 22 June 2017.

recognition of skills and qualifications, regional organizations and partners with critical guidance on how to respond to digitization in a proactive manner and seize its benefits for recognition of skills and qualifications, lifelong learning, and more broadly for sustainable development.

4. Research design

This report is based on a review of available and current literature and a series of interviews.⁷ Interviewees were selected based on their expertise and representation across the following broad categories: policy-makers, researchers, quality assurance bodies, implementing bodies, global initiatives and unregulated sectors. The overall 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. It is our aim that the study will contribute to a new narrative of reforming qualifications systems and recognizing skills and qualifications within and between countries.

5. A note on nomenclature

Credential. Electronic or paper-based representation of the different types of learning acquired by an individual (adapted from Keevy and Chakroun, 2015). A paper-based representation is most commonly referred to as a transcript.

Digital badge. A clickable graphic that contains an online record of 1) an achievement, 2) the work required for the achievement, 3) evidence of such work, and 4) information about the organization, individual or entity that issued the badge (Lemoine and Richardson, 2015).

Digitization. The conversion of information into a digital form that can be used by the internet, mobile phones, and all other tools that collect, store, analyse and share information digitally.

Immutable record: An unchangeable record whose state cannot be modified after it is created.

Interoperable. The exchangeability between a range of products, or similar products from several different providers, or even between past and future revisions of the same product. Interoperability may be developed post-facto, as a special measure between two products, while excluding others, by using open standards. When a vendor is forced to adapt its system to a dominant system that is not based on open standards, it provides not interoperability but compatibility.

Micro-credential. A term that encompasses various forms of credential, including 'nano-degrees', 'micro-masters credentials', 'certificates', 'badges', 'licences' and 'endorsements'. As their name implies, micro-credentials focus on modules of learning much smaller than those covered in conventional academic awards, which often allow learners to complete the requisite work over a shorter period. In their most developed form, micro-credentials represent more than mere recognition of smaller modules of learning. They form part of a digital credentialing *ecosystem*, made possible by digital communications technologies establishing networks of interest through which people can share information about what a learner knows and can do (Milligan and Kennedy, in James et al., 2017).

Open badge. Visual digital tokens of achievement, affiliation, authorization or some other trust relationship sharable across the web. Open badges represent a more detailed picture than a curriculum vitae (CV) or résumé as they can be presented in ever-changing combinations, creating a constantly evolving picture of a person's lifelong learning.

Open standard. A technical standard made available to the general public that is developed (or approved) and maintained via a collaborative and consensus-driven process. Open standards facilitate interoperability and data exchange among different products or services, and are intended for widespread adoption.

Portability. The ability to share and translate credentials from one context to another and to represent them in different combinations for different audiences (Barabas and Schmidt, 2016).

Professional standard. A public statement that describes the professional knowledge, professional practice and professional engagement required of someone working in a professional capacity.

Qualification. A proxy for the different types of learning acquired by an individual using learning outcomes (adapted from Keevy and Chakroun, 2015). A formal acknowledgement

⁷ Interviews (*or in these cases written submissions) obtained information from Loukas Zahilas (CEDEFOP), Emmanuel Chomarat and Mireille Richard (VerifDiploma); Beverley Oliver (Deakin University)*; Herman De Leeuw (GDN)*; An-Me Chung (Mozilla Foundation); John Lesperance and Venkataram Balaji (COL); Cloud Bai-Yun (UK NARIC)*; Joseph Thompson (AidTech); Rick Torres (National Student Clearinghouse, USA); Edward Wenjun (CSCSE); Stephan Vincent-Lancrin (OECD); Michael Sessa (PESC); Delphine Poschman (Global Philanthropy, JP Morgan Chase); Chris Whelan (Universities New Zealand); Ameer Shroff (CDS India)*; Mike O'Reilly (AACRAO); Grant Klinkhum (NZQA); and Nourah Al'Matrooshi (NQA UAE)*. We also recognize the time and effort taken by many of the interviewees to provide substantive inputs during the peer review process early in 2018.

of successful completion of a course, including meeting its designated learning outcomes. Terms typically used for qualifications include degrees and certificates. Completion of a long-term course leads to a macro-qualification: for example, a traditional degree typically requires three years of full-time study or the equivalent; courses of between one and three years might culminate in the award of a diploma. Completion of a shorter course can lead to a more restricted form of qualification, increasingly referred to as a micro-credential.

Recognition of learning. The principles and processes through which the knowledge, skills and competences of a person are made visible, mediated and assessed for the purposes of certification, progression and professional standing (Keevy and Chakroun, 2015).

Verification. To check the source and authenticity of a credential. This is a fundamental aspect of increasing trust in novel forms of credentials and assessments based on big data (adapted from Barabas and Schmidt, 2016).

World reference levels. A translation device that would be able, in the future, to act as a neutral reference point for the recognition of learning across countries and regions (Keevy and Chakroun, 2015).

6. Structure of the report

The remainder of this paper is structured as follows. Chapter 2, 'New and emerging trends in the digitization of credentials', maps key initiatives on digitizing skills, credentials and certificates, including national, regional and cross-regional initiatives. The trends reviewed include digital badges, open learning and digital repositories, as well as the technologies involved in the digitization of credentials, including blockchain and artificial intelligence. Chapter 3 starts to develop the notion of a digital ecosystem, as it outlines the various actors involved in digital credentialing. Chapter 4 explores key policy implications to be considered, including the development of standards, both technical and professional. It outlines policies and policy measures that countries and organizations are taking to engage education and more specifically recognition of skills and qualifications in a digital transformation, and the complementarity of these policies with non-digital aspects such as quality assurance, governance and the use of learning-outcomes. In the final chapter we reflect on the findings and propose some considerations for enhancing the synergies between digital developments and the implementation of the new generation of qualifications frameworks internationally, as well as the implications for WRLs.

Chapter 2. New and Emerging Trends in the Digitization of Credentials

1. The intersection between macro and micro-credentials

The intersection between macro and micro-credentials is a dynamic and evolving space, with a range of government, inter-government, for-profit and non-profit actors vying for attention. Many of these debates started in the realm of the internationalization of education, but have evolved into forms of commercialization and self-interest.

The conversion of information through the internet and other tools has transformed the way people live, work, learn and recognize learning. Numerous examples could be given, but let us mention just a few. Europass, and soon Europass+2, have resulted in the integration of platforms including CVs, qualifications, and self-assessment tools (Zahilas, 2017). The European Skills Panorama, which is being developed in parallel with Europass, allows for the monitoring of skills anticipation and skills assessment at the national and European level. The multilingual classification of European Skills, Competences, Qualifications, and Occupations (ESCO) introduces a standard terminology in 25 European languages, and categorizes skills, competences, qualifications and occupations relevant for the EU labour market and education and training.⁸ The UNESCO cross-border guidelines (Vincent-Lancrin et al., 2015) are to be reviewed to include digital elements (Vincent-Lancrin, 2016; Credential Engine works to improve transparency in the credentialing marketplace (Sessa, personal communication, 2017), and JP Morgan Chase is supporting this work⁹ (Poschman, personal communication, 2017). The IMS Digital Credentialing initiative is a collaboration between IMS, the Mozilla Foundation and Collective Shift/LRNG to help ensure the sustainability of the future Open Badges ecosystem. Effective January 2017, IMS Global assumed responsibility for the continuing evolution of the Open Badges specification.¹⁰

An important early starter to mention is the Electronic Database for Global Education (EDGE) developed by the American Association of Collegiate Registrars and Admissions Officers (AACRAO) (O'Reilly, personal communication, 2017).

EDGE has been a forerunner in the credentials industry in the United States of America, using an online format that allows for dynamic updates. The European equivalent is the ENIC-NARIC (European Network of Information Centres – National Academic Recognition Information Centres) network, which has strengthened collaboration between countries and contributed directly to more sophisticated credential practices.

South Africa stands out as an example of the development of a sophisticated relational database linked to its qualifications framework. The National Learners' Records Database (NLRD) has allowed for the verification of qualifications to be handled from within the national system. Not all governments have repositories of degrees (Chomarat and Richard, personal communication, 2017) with this level of sophistication, particularly in the developing world.

The Postsecondary Electronic Standards Council (PESC), based in Washington DC, is another important player in the world of digital credentials. PESC has made an important contribution with the development of Common XML Credential for Certificates, Degrees, and Diplomas, as well as with the development of a Degree Supplement standard, and most recently the formation of an inter-agency committee of unaffiliated standards organizations (Sessa, personal communication, 2017).

Three other examples are described by Oliver (2017). EdX, which was founded by Harvard University and the Massachusetts Institute of Technology (MIT) in 2012, now has more than eighty-five global partners. EdX Verified Certificates are available for a fee, and require learners to verify their identity before they can receive their certificate. Coursera, which was founded in 2012 at Stanford University, offers learners the opportunity to complete individual courses or specializations. Specializations consist of a series of related courses followed by a peer-assessed capstone project. Udacity, with Google, Facebook and Salesforce as partners, is building an online university that delivers credentials endorsed by employers at a fraction of the cost of traditional institutions. FutureLearn is a UK-based equivalent, while

8 <https://ec.europa.eu/education/>, accessed 23 June 2017

9 See www.credentialengine.org

10 See www.imsglobal.org/initiative/enabling-better-digital-credentialing#BEE

Swayam is a new development in India that shows great potential.

Three important trends in the digitization of credentials that deserve closer scrutiny are discussed below: open learning, digital badges and digital repositories.

2. The open education/learning movement

A key moment for the open education movement was the adoption of the Cape Town Open Education Declaration (2007), which states that:

open education is not limited to just open educational resources. It also draws upon open technologies that facilitate collaborative, flexible learning and the open sharing of teaching practices that empower educators to benefit from the best ideas of their colleagues. It may also grow to include new approaches to assessment, accreditation and collaborative learning.¹¹

According to Vincent-Lancrin, openness has become a key feature of our societies, and as a result is impacting on the way we think about education:

[the] rise of the open software movement has inspired a broader culture of openness in OECD societies. With open data, open knowledge, open science, open innovation, open learning, open education, open migration, open networking, open government, openness has become a key feature of our societies, and its implications, a key dimension of strategic foresight. (Vincent-Lancrin, 2016, p. 3)

Vincent-Lancrin (2016) suggests a differentiation between open enrolment institutions and open universities, and open learning. The former award degrees: prominent examples are the UK Open University, India's Indira Gandhi National Open University (IGNOU), the Arab Open University and the University of South Africa (UNISA). On the other hand, open learning 'grants students with sub-degrees (certificates, etc.), which are not equivalent to higher education degrees; often, it does not lead to any credential. Open learning is in fact not structured around degrees, but rather around smaller bits of knowledge such as "resources" or courses' (Vincent-Lancrin, 2016, p. 8). This distinction between degree awards and micro-credentials is important and is a common thread that runs across the digitization debates.

Open education resources (OERs) have been part of the education and training landscape for several decades. In many ways they represent the move towards free and high-quality access which forms the foundation upon which open degrees and micro-credentialing have developed.

OERs are:

teaching, learning and research materials in any medium, digital or otherwise, that reside in the public domain or have been released under an open license that permits no-cost access, use, adaptation and redistribution by others with no or limited restrictions. Open licensing is built within the existing framework of intellectual property rights as defined by relevant international conventions and respects the authorship of the work. (UNESCO, 2012)

The five freedoms most commonly exploited by OER adopters under Creative Commons licences are formulated as the '5Rs':¹²

- Retain: the right to make, own and control copies of the content (for instance, to download, duplicate, store and manage).
- Reuse: the right to use the content in a wide range of ways (such as in a class, in a study group, on a website, in a video).
- Revise: the right to adapt, adjust, modify or alter the content itself (for example, to translate the content into another language).
- Remix: the right to combine the original or revised content with other material to create something new (such as to incorporate the content into a mashup).
- Redistribute: the right to share copies of the original content, your revisions or your remixes with others (for instance, to give a copy of the content to a friend).

At the Second OER World Congress in Ljubljana in September 2017, an Action Plan for Mainstreaming OER in support of SDG 4 was accepted. This Plan is the starting point for a Recommendation for future international collaboration in the field of OER, to be prepared by UNESCO and its Member States before the 2019 session of the General Conference.

Organizations such as the Commonwealth of Learning (COL) and OER Commons have been instrumental in this regard: 'Open Educational Resources (OER) offer opportunities for systemic change in teaching and learning content through engaging educators in new participatory processes and effective technologies for engaging with learning.'¹³

11 www.capetowndeclaration.org/

12 <http://opencontent.org/definition/>, accessed 9 June 2017.

13 www.oercommons.org, accessed 12 August 2017.

An example where open learning is gaining traction is massive open online courses (MOOCs). Described as a clear ‘disruptive challenge’, able to ‘tap globally available offerings without firm attachment to any particular institution’ (French and Kelly, 2017, p. 27), MOOCs have emerged since 2012 (Oliver, 2016a) based on a variety of platforms mainly across the USA and Europe, and more recently also the Arab States, South America and Asia. Examples include Coursera, Edx, FUN, futurelearn, iversity, Rwaq, veduca and XuetangX (Music, 2016, p. 9). The number of registered users increased to an estimated 35 million in 2015, from an estimated 16–18 million in 2014 (Shah, 2015 in Music, 2016), while 4,200 MOOCs were available to students by 2016, ‘which is more than the preceding three years combined’ (Music, 2016, p. 4). MOOCs are mostly free of charge, ‘unless the learners want to get some kind of certification of the knowledge and competence they have acquired’ (Vincent-Lancrin, 2016, p. 9). An important area of research that lies beyond the limits of this report is the pedagogical practices that are required in the delivery of MOOC courses. They are demanding pedagogically because of the number of distractions to which learners can be exposed (Verbert et al., 2016).

Open degrees allow students the flexibility to arrange their own curriculum by combining courses. While there are many benefits to such openness, ‘including the the flexibility to change their study path ... [and] to study what corresponds the most to their professional needs and their personal aspirations’, there are also risks in that the ‘that students’ qualification is not immediately legible to employers’ (Vincent-Lancrin, 2016, p. 12). Referred to as *diplômes blancs* in the French context, open degrees are also offered by the University of Paris Descartes.

3. Digital badges

A discussion on digital credentials would be incomplete without reference to digital or open badges. These visual tokens of achievement are described as a ‘new way to capture and communicate what an individual knows and can demonstrate’ (Finkelstein et al., 2013, p. 1, quoted in Mah, 2016), effectively providing a technological solution to the problem of representing learning beyond qualifications.

Badges can be collected through social media and other platforms, such as LinkedIn, Jive, Fidelis, Credly and Mozilla, but also through more formal associations with established institutions, such as Coursera affiliated with Stanford University, Open2Study affiliated with Open Universities Australia, and Passport with Purdue University (Oliver, 2016, in Mah, 2016). Multinationals including IBM and Accenture

are also increasingly developing their own badges for both their staff and the wider public. IBM offers a range of badges including Knowledge, Skill and Proficiency. IBM promotes its Open Badge programme as a way for professionals to display and share their accomplishments. The IBM website proclaims, ‘Anyone can get an IBM Open Badge, except a few which are limited to IBM employees only.’¹⁴

Badges are associated with competency approaches to education, and as a result, claim to ‘help speed the shift from credentials that simply measure seat time, to ones that more accurately measure competency’ (Duncan, 2011, in Ifenthaler et al., 2016, p. 24). Duncan further claims that ‘badges can help account for formal and informal learning in a variety of settings’. Digitalme¹⁵ is a good example of an initiative that is using digital credentials to ‘close the gap between the skills employers need and the skills they can see’. Mah (2016) draws on various sources to further suggest that digital badges can play five main roles in education: motivation, recognition of learning, signalling of achievements, capturing of learning paths, and the potential to contribute to student retention in higher education.

Badges are viewed as examples of micro-credentials, representing discrete skills sets that can be grouped or ‘stacked’ to form a larger or macro-credential. Oliver (2016b) suggests that digital credentials that use badging have the following affordances:

- Granular: more than simply communicating marks and grades, they can pinpoint where skills and competencies – for example, innovative thinking or teamwork – have been demonstrated.
- Stackable: because they are digital, they can be added to credential repositories, mapped to qualifications frameworks, and more easily be understood in terms of eligibility for credits in other credential systems.
- Evidentiary: they can point the reader of the credential directly to learning evidence created by the learner.
- Personalized: because they can more accurately represent each learner’s achievements, highlighting where skills or outcomes were achieved above the minimum standard.
- Machine-readable: if built using open technical standards, they enable rich analytics, showing, for example, which graduates in a cohort excelled in communication skills or teamwork.

An important feature of digital badges is the claim that generic skills, also referred to as twenty-first-century skills, soft skills, and more recently also linked to the notion of global

¹⁴ www.ibm.com/training/badges/

¹⁵ www.digitalme.co.uk, accessed 10 June 2017.

citizenship education (GCE), can adequately be represented (Mah, 2016).

While there is a strong push towards investing, developing and using digital badges on large scales by corporate bodies, universities and training providers, several issues and limitations remain, including the following.

Security: As in other sectors, it is still easy to forge many things online, from the identity of the learner to the veracity of test responses to the bona fides of the granter of the badge or certificate.

Users' perception: A recent survey by Extreme Networks showed that 46 per cent of participants believed that digital badging is not yet widely recognized, and 34 per cent of participants did not fully understand the concept. The same survey also showed that over 60 per cent of participants believed that digital badges will eventually either supplement or entirely replace diplomas and course certificates.¹⁶

Quality assurance and transparency: The mass awarding of badges with little or no quality assurance and the wide range of sources of badges will affect credibility and visibility, with the risk of what could be called a 'Jungle of Badges' developing.

Access to the internet: Individuals living in developing countries face additional problems related to access to the internet, including lack of infrastructure; low incomes and problems of affordability; limited user capabilities, including basic literacy and digital literacy; and a dearth of incentives for access, including lack of awareness, relevant content, and cultural or social acceptance (Schmida et al., 2017).

There are also necessary conditions under which digital badges can lead to better outcomes. According to Mozilla's *Promising Practices of Open Credentials: Five Years of Progress* (2016),¹⁷ open digital badges matter to students, employers and educators when they recognize dispositions, roles and incremental skills not traditionally measured, including essential twenty-first-century skills and digital literacies; represent learner autonomy; are co-designed with key stakeholders; explicitly state the expectations about what is required to be successful; provide students with something tangible they can take with them; align with common standards and competencies; are recognized as meaningful and consequential by external partners; and provide employers with a quick and visual way to understand the skills set of potential applicants.

4. Digital repositories

The third trend we look at is the growth of digital learners' records repositories. While many of these repositories have been in place for a few decades, there is no doubt that the new wave of digitization being experienced has impacted directly on how they function, and how data in them can be harvested. According to Bai-Yun (personal communication, 2017), digital student data repositories fall into at least four main categories:

- national, government-run diploma registers;
- commercial diploma registers linked to student records systems;
- commercial diploma supplement registers linked to student records systems;
- bespoke databases designed and administered by individual education institutions or consortia of education institutions.

Bai-Yun (personal communication, 2017) argues that these repositories also range in functionality, for example:

- issuing students with a stand-alone, certified electronic document such as a 'secure' PDF document;
- making electronic documents available for sharing through an online database;
- user-oriented student data access solutions – which can include formative and summative achievement information as well as academic and co-curricular achievements;
- other methods being explored by some education institutions, such as open badges.

The problem, according to Bai-Yun (personal communication, 2017), is that these repositories use disparate technologies and are often incompatible. As a result, the end user has to use different systems to access different data from multiple sources: 'Incompatibility and interoperability is a problem, and there have been some efforts to overcome the issues, for example in the UK with the HEDD' (Bai-Yun, personal communication, 2017), although Bai-Yun adds that evidence of impact is not yet available.

An integral feature of digital repositories that contributes to their credibility is their ability to provide a dataset that is as comprehensive as possible for the country or sector they represent (Chomarat and Richard, personal communication, 2017). This is also referred to as the ability to be the 'trusted custodian' (Thompson, personal communication, 2017). The

16 See: https://content.extremenetworks.com/extreme-networks-blog/how-we-use-digital-badges-for-recognition-and-motivation-at-extreme-networks?_ga=2.182621414.1133571021.1517737521-894459921.1517737521

17 Also see open badges V2.0: www.imsglobal.org/sites/default/files/Badges/OBv2p0/index.html

China Higher Education Student Information and Career Center (CHESICC) is a case in point:

CHESICC has pioneered student data digitization in China. Its database, which includes students nationwide, contains 864 million pieces of data and each year 100 million more pieces of information are added. Since 1991, CHESICC has registered 117 million qualifications, with annual growth of 10 million qualifications. Its qualification verification service has checked 70 million student records, and produced four million online and one million paper verification reports. (AACRAO, 2014, p. 12)

The National Student Clearinghouse (NSC) in the USA is another example as it includes 96 per cent of diplomas and qualifications awarded in the country (Torres, personal communication, 2017). The NSC was established in 1993. In 2014 it launched eTranscripts, and in 2015 it established Reverse Transfer, the first national platform in the USA for exchanging reverse student data that enables the awarding of specific degrees. Today the NSC offers services ranging from data exchange to financial aid, research and also academic verification.

The Lumina Foundation launched a centralized credential data platform in December 2017 called the Credential Registry, a common credentialing language for credential evaluation, a digital application to search for credentialing information, and an Application Programming Interface (API) tool to allow organizations to continuously upload up-to-date information to the Registry.

In France, the government is launching a unique digital database for verification of qualifications.¹⁸ Initially, it is hoped that the database will hold data on 500,000 higher education qualifications and 1.6 million from secondary level issued at the end of the 2016–17 academic year. The service will then be rolled out to cover the past decade and a half, with 25 million qualifications covered.

Hedda.ac.uk is a very similar system (however, it is fee-based) to that proposed in France. Backed by the UK Government, so far it contains candidate information from 26 UK universities, enabling higher qualifications for a quarter of UK graduates to be verified through a secure online service. Since launching it has processed more than 90,000 qualification checks and identified over 200 bogus institutions.

5. Digitization technology standards

The list of digitization technologies, also referred to as standards, can be quite extensive, and it is not the purpose of this paper to provide a detailed technical account of each one. A high-level summary of some of the available technologies is provided below, and followed by a more detailed discussion on blockchain as an emerging new technology that is showing great potential for application in educational contexts.¹⁹ The digitization technologies are essential elements of the ecosystem of digital credentials, underpinning all the other elements.

Experience API (xAPI) allows statements about learning experiences to be delivered to and stored securely in a Learning Record Store (LRS), and it is in the LRS that badge achievements can be managed and tracked (Experience API Working Group, 2013, in Ifenthaler et al., 2016).

Extensible Markup Language (XML) is used to describe data. The XML standard is a flexible way to create information formats and electronically share structured data via the public internet, as well as via corporate networks. The design goals of XML emphasize simplicity, generality, and usability across the internet. It is a textual data format with strong support via Unicode for different human languages. Although the design of XML focuses on documents, the language is widely used for the representation of arbitrary data structures such as those used in web services. Several schema systems exist to aid in the definition of XML-based languages, while programmers have developed many application programming interfaces (APIs) to aid the processing of XML data. The PESC XML-based data standard for a *Common Credential for Certificates, Degrees and Diplomas* is an example of a standard that is designed for both electronic certification production and recording credential learning records.

The **JavaScript Object Notation (JSON)** format is often used for serializing and transmitting structured data over a network connection. It is used primarily to transmit data between a server and web application, serving as an alternative to XML.

PDF files are compatible across multiple platforms. A PDF format represents a document independently of the hardware, operating system and application software used to create the original file. It was designed to create transferable documents that can be shared across multiple computer platforms.

¹⁸ <https://diplome.gouv.fr>

¹⁹ Sources: Sessa (2017); Wikipedia; legalscams.com

Electronic data interchange (EDI) provides a technical basis for automated commercial ‘conversations’ between two entities, either internal or external. The term EDI encompasses the entire electronic data interchange process, including the transmission, message flow, document format, and software used to interpret the documents.

Digital signature is a mathematical scheme for demonstrating the authenticity of digital messages or documents. A valid digital signature gives a recipient reason to believe that the message was created by a known sender (authentication), that the sender cannot deny having sent the message (non-repudiation), and that the message was not altered in transit (integrity). Digital signatures are a standard element of most cryptographic protocol suites, and are commonly used for software distribution, financial transactions, contract management software, and in other cases where it is important to detect forgery or tampering.

Open format is a file format for storing digital data, defined by a published specification usually maintained by a standards organization, and which can be used and implemented by anyone.

The key consideration for all these and future technologies is interoperability. As pointed out by Sessa (personal communication, 2017), this can only be achieved through ‘data standards, that is the agreement on the vocabularies, code sets, and supporting protocols – a common data language that enables the removal of human intervention and the ability for machine-to-machine data exchange’. Digitary (see Wilson and Argles, 2010) is a good example of a platform that has been able to harness existing technologies in a manner that provides a seamless solution to users²⁰ in Europe, Australia, the United Kingdom, China and the USA.

6. Blockchain in certification

A discussion of technologies related to the digitization of credentials would be incomplete without reference to ‘blockchain’, which is a recurring theme in this discourse (Smolenski, 2016; EC, 2017; Skella, 2017). Blockchain technology has its origin in the finance sector, but is rapidly expanding to applications in elections, music, data storage, energy and also digital credentials.

Blockchain is an important new technology that is being widely used and considered for application for digital credentials. Smolenski (2016) considers that blockchain

technology is ideal as new infrastructure to secure, share and verify learning achievements.

According to Verbert and colleagues (2016, p. 490), ‘the distinguishing elements of the blockchain are that it is a single linked record of digital events, stored on each participating computer’. According to them a blockchain has the following properties:

- The entire record is distributed over a wide network of participating computers and so is resilient to loss of infrastructure.
- It is possible to confirm the identity of any addition or modification to the record.
- Once a block has been added by consensus among participants, it cannot be removed or altered, even by the original authors.
- The events are publicly accessible, but not publicly readable without a digital key.

Blockchain was originally developed for the Bitcoin digital payment system:

The blockchain is a long chain of linked data items stored on every participating computer, where the next item can only be added by consensus of a majority of those participating. There are public blockchains that anyone can access and potentially add to, and there are private blockchains used within an organization or consortium. (Verbert et al., 2016, p. 490)

The implications for digital credentials include the ability to provide ‘a single secure record of educational attainment, accessible and distributed across many institutions’ (Verbert et al., 2016, p. 490).

Verbert and colleagues (2016) also suggest that blockchain can be used to ‘open up the system of scholarly reputation currently associated with academics’, and that ‘reputation could be traded, by being associated with academic awards, as well as being put up as collateral for important ideas or to validate the adding of new block to the chain’. While the last two suggestions may seem far-fetched, the first is certainly not. A number of institutions have reported experimenting with blockchain, or are at the very least exploring the potential, including UK NARIC, PESC, AACRAO, CHESSIC, Mozilla and Deakin University.

For example, in the USA, Holberton School²¹ has started to deliver certificates in a blockchain with a view to simplifying the verification process by employers, and countering forged certificates and false résumés. Every Holberton digital certificate will be issued in a secure environment,

²⁰ See www.digitary.net

²¹ See: <https://blog.holbertonschool.com/using-the-blockchain-to-secure-and-authenticate-holberton-school-certificates/>

which requires a 256-bit encrypted private key and two-factor authentication to access the interface that will generate, sign and insert the certificate into the blockchain, making the certificate's content sealed and tamper-proof. In addition, each graduate will be given a paper certificate, and a digital certificate number (DCN). This DCN can be included on résumés, so that any employer can easily verify the validity of the certificate. MIT Media Lab is also using Blockcerts for issuing digital certificates to groups of people in its broader community, such as Directors Fellows (Barabas and Schmidt 2016). Pilots have also been conducted in a few EU universities, including the University of Nicosia, Open University UK and a nation-wide experiment in Malta (EC, 2017).

A recent EC report (2017) exploring the introduction of blockchain in education found that several areas of education and training will be impacted by the adoption of blockchain technology, including the acceleration of the end of paper-based system for certificates; reinforcement of users' ability to automatically verify the validity of certificates without the need to contact the organization that originally issued them; and creation of data management structures where users have increased ownership and control over their data and as consequence organizations' data management costs are reduced.

The study further concludes that the benefits of blockchain are only achieved through open implementations of technology, which utilize open source software, use open standards for data, and implement self-sovereign data solutions.

Blockchain is a relatively new technology and it will take time to establish its use widely and assess its impacts, and how it could complement and develop within approaches to digital repositories and credentials.

Finally, a rarely mentioned downside of blockchain is the enormous power requirements. A recent article in the *New York Review of Books* (Halpern, 2018) says that the validation process supporting bitcoin (just one of many digital currencies running on blockchain technology) is so power-intensive that 'the power consumption of bitcoin mining now exceeds that of Ireland and is growing so exponentially that it will surpass that of the entire United States by July 2019'.

7. Artificial intelligence

Artificial intelligence (AI) is another important technology that is being developed at a rapid pace. Increased access to big data, while not the norm yet, 'can provide issuers insights on specific skillsets, high volume activities, and global trends; it should not be ignored' (Ifenthaler et al., 2016, p. 85). According

to AACRAO (2014, p. 5), 'Big data has the potential to provide a new level of inferences and insights about education worldwide.' For instance, AI-powered machines are making headway in student assessment. Companies like GradeScope already use computer vision and machine learning to grade students' work quicker than a teacher could (McKinsey, 2017). In the future, advances in natural language, virtual reality and augmented reality could expand AI's usefulness in automatically assessing other types of skill including transferable skills and job-specific skills. AI can be also used to automatically access, process and compare credentials at a large scale.

While AI is making inroads in education, for example with assessment and grading, it still has a long way to go. We need to think more carefully about what AI does well and what humans do well. For example, AI can provide intelligent tutoring, but only in well-defined, narrow domains for which we have lots of data. Learning analytics can analyse learner behaviour and teacher activities so as to identify individual needs and preferences to inform human intervention. Humans, while inefficient at searching, sorting and mining data, for example, are good at understanding, empathy and relationships.

In fact, of all the sectors McKinsey & Company examined in 2016 (Chui et al., 2016), the technical feasibility of automation is lowest in education, at least for now. The report considers that the essence of teaching is deep expertise and complex interactions with other people, things that AI is not yet good at. Some experts have predicted that in the future robotic systems might be able to assess learning and skills as students perform authentic tasks or projects, gradually eliminating the need for formal assessments. AI could for example detect what foundational skills or understanding a particular student has or does not have as they complete a project. It is hard to say where all of this is going, but AI could take the pressure off formal testing.

Hence, AI solutions based on big data, and also those that are increasingly learning from the tacit abilities of humans, and the extent to which they can contribute to the recognition of learning, are areas to watch closely. However, as was noted in a McKinsey study on AI (2017), success hinges not only on technical issues but on ethical issues, starting with who owns data on students, who can see it, who can use it, and for what purposes.

8. Conclusion

This chapter highlighted the dynamic intersection between macro and micro-credentials. While credentials were traditionally used to signal major achievements in education,

learning or the acquisition of skills (a vocational qualification or a college diploma, for example), technology seems to be accelerating the push to recognize and 'credential' more minor achievements and learning outcomes. At some level, micro-credentialing is made possible by the use of learning outcomes and technology: distinct sub-sets of learning outcomes can be removed from larger learning sequences, and computer assessments can (to a reasonable degree) assess the mastery of students. At the same time, innovations enabled by technology (for example, MOOCs) necessitate micro-credentialing because of the reduced level of direct human interventions (for example, there is little or no use of human instructors) in the teaching and learning processes.

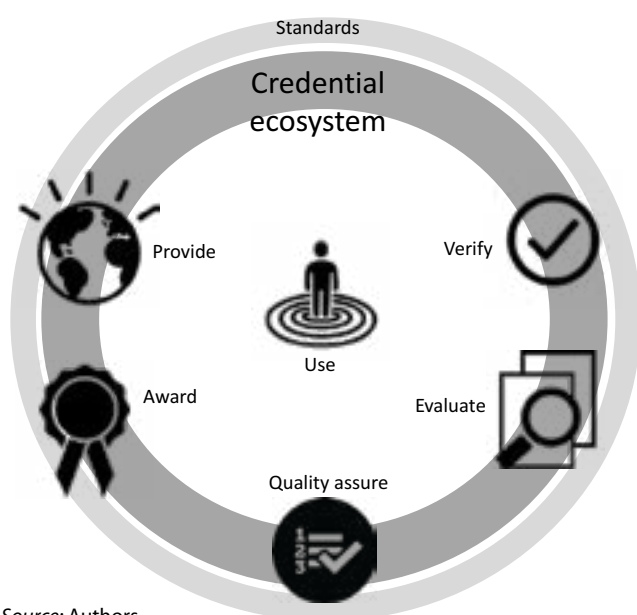
This chapter presented the range of technologies used to support digitization of credentials and highlighted the progress and limitations to date. In the next chapter we build on these emerging insights as we take a closer look at the ecosystem within which digital credentials exist.

Chapter 3. Towards a Digital Credentials Ecosystem

Chapter 2 demonstrated the significant opportunities that digital technology brings to the recognition of skills and qualifications. Several building blocks are likely to be disrupted by fast-developing technology, including the award of qualifications, licensing and accreditation, management of students' records and learning achievements, intellectual property management and payments for services.

1. The possible structure of the ecosystem

Figure 1 The digital credentials ecosystem



Source: Authors

The literature on digital credentials is awash with references to the need for a well-defined and understood ecosystem of actors and functions:

Digital micro-credentials may or may not become an enduring feature of the tertiary education landscape, and are certainly not based on educationally novel practices. But they raise fundamental questions for the higher education sector about the university's ongoing role in warranting and crediting in an era dominated by digitization. (James et al., 2017, p. 42)

Within the limited scope of this report we propose to develop the model illustrated as Figure 1. It is made up of seven interrelated sectors and groups of stakeholders, anchored to specific functions in the digital credentials environment.

Use. These are the users of credentials, notably learners, who are placed at the centre of the system (AACRAO, 2014). Of course, providers can also be users, as can employers.

Provide. Here we refer mainly to education and training institutions and the emerging variety of for-profit and non-profit digital platforms, such as Coursera, FutureLearn, Credley, Verifdiploma and Mozilla.

Award. Awarding bodies in the traditional sense are institutions and professional bodies. To this list we need to add employers, MOOCs, and in some instances also the owners/hosts of digital platforms such as IMS Global.

Quality assure. This is where the line between macro and micro-credentials is probably the clearest. The lack of quality assurance poses a significant threat to the credibility of digital credentials, and also sets constraints on the flexibility of traditional degrees.²² The issues of trust, and particularly authentication and authorization, are critical in this context.

Evaluate. The evaluation of credentials has been owned by credential evaluation agencies, such as the ENIC-NARIC network and some qualifications authorities. The value judgments required (Bai-Yun, personal communication, 2017), and the relative opaqueness of the methodologies employed, have resulted in some level of protection, but this has been challenged by the increasing use of learning outcomes in qualifications frameworks nationally and regionally, and at present, also by the new forms of credential that are the topic of this paper.

Verify. The range of both public and private verification agencies that have emerged in the last five years has increased substantially, and can be directly attributed to the affordances related to the digitization of credentials. The notion of a clearinghouse is closely associated with this function (Torres, personal communication, 2017).

²² In 2016 the Open Badge for Education Extensions (OBEE) Initiative's work centred around exploring how the addition of 'Issuer Accreditation' and 'Assessment' extensions to the Open Badges specification might help communicate the rigour with which badge earners' activities were scrutinized before a decision was made by the badge issuer to award the badge. The Issuer Accreditation extension will provide a reference to single or multiple accreditation bodies that certify the badge issuer. The Assessment extension will provide information about single or multiple assessments that are required as part of the badge issuance process.

Convene. The last sector is also the most critical. International agencies such as UNESCO and the Organisation for Economic Co-Operation and Development (OECD) have a role to play, and increasingly so do open communities and networks that

have developed organically and comprise an eclectic mix of actors.

Table 1 presents a high-level overview of the digital credentials ecosystem outlined in this report.

Table 1 The digital credentials ecosystem

Function	Typical actors	Artefacts
<i>Use</i>	Students, recruitment agencies, citizens, employers, professional associations, immigration services	Academic record, transcript, digital badge, qualifications
<i>Provide</i>	Academic institutions, digital platforms	Awards, student account, IT platform, digital badge, datasets, repository
<i>Award</i>	Institutions, faculty vendors, suppliers, online communities	Awards, credentials
<i>Quality assure</i>	Ministries, qualifications authorities, sectoral bodies, governments and government agencies, standards bodies	Policies, guidelines
<i>Evaluate</i>	ENIC-NARIC network, for-profit agencies, Association for International Credential Evaluation Professionals (TAICEP)	Transcript, evaluations
<i>Verify</i>	Verifiers (non-profit) and non-profit, qualifications agencies, government departments	Verification certificate
<i>Convene</i>	UNESCO, World Bank, OECD, European Commission, African Development Bank governments (and government agencies), GDN	Minutes, conventions, conference proceedings

Sources: Authors based on Chomarat and Richard, De Leeuw, Sessa, Shroff, Zahilas, personal communications, 2017

The ecosystem hinges also on the range of tools and technologies available. Dowling's (2018) analysis of the different architectures available regarding their scope and functionality, impact on mobility of learners, security and participation is highly relevant in this context. The table 2 below provides key advantages and challenges.

Architecture	Scope and functionality	Mobility	Security, Trust, Privacy	Participation
<i>Central Repository</i>	<p>A central database containing credential data is populated by education providers.</p> <p>Employers and other third parties check data using an online web lookup.</p>	<p>The student is not part of the digital process so does not have a digital artefact per se, and cannot control access to their online record.</p>	<p>For privacy, student consent is either implied (as the record is provided by the education provider) or paper-based (where the third party needs to prove that they have student consent to verify by uploading a signed consent form).</p> <p>A central data store increases risk of attack / security breach.</p> <p>To establish trust in the service, communications by education providers with third parties are key to adoption.</p>	<p>The simplified workflow makes these systems easier to build and therefore participate in.</p> <p>However, participants ultimately need to populate data into repository.</p> <p>Technical complexity of participation usually depends on the complexity of the data needed by the repository.</p>
<i>Exchange Network</i>	<p>A secure B2B network between education providers enabling them to send and receive records.</p>	<p>Sometimes providers send records directly to other providers without student involvement.</p> <p>Consent is either implied, or students can initiate the “push” of records themselves via systems connected to the network.</p>	<p>Being a closed network by definition, participants are known and vetted, enabling trust.</p> <p>Underlying secure communications protocols for exchange means that participants can be sure that what they receive is authentic.</p>	<p>Because implementation involves technical data standards and exchange protocols, the technical bar to participation is relatively high for education providers to send via the network. It is usually easier to receive via vendors.</p>
<i>Hub and Spoke</i>	<p>Hybrid of (1) distributed repositories (one per school), connected via (2) an exchange network, with (3) student & third party portals and (4) an external integration hub</p>	<p>Students have 24/7 access to and control over access to their records</p> <p>Zero intervention required by education providers in order for students to share records with a third party</p>	<p>Education providers each maintain their own repositories</p> <p>Cryptographic signing + access control ensures record security, authenticity, and integrity</p> <p>Student controls who can access their records, and for how long.</p> <p>Various methods of verification, via the network or via a trusted web portal</p>	<p>Participants ultimately need to populate data into their repository.</p> <p>Complexity is dictated by the data to be exported. Simpler alternatives available (PDF) where data is difficult to export.</p>
<i>Badge Framework</i>	<p>Badges are images (PNG files) with embedded data according to an open standard</p> <p>Supporting workflow elements defined for issuing, receiving, and verifying badges.</p>	<p>Students store and control sharing of their badges.</p> <p>Badges are fine-grained, shareable, and stackable credentials</p>	<p>Badges are usually trusted based on where they are hosted, or cryptographic signing by the issuer.</p> <p>Endorsement / web 2.0 model</p> <p>Anybody can issue a badge for anything. This has created a negative perception of badge trustworthiness in a formal context.</p>	<p>It is easy to issue badges so participation is straightforward.</p>

Public Blockchain	<p>Hashes of records are written to a public blockchain by education providers.</p> <p>The records themselves are given to the student.</p> <p>Third parties verify records received from students against the public blockchain</p>	<p>Students possess the record themselves, and therefore control sharing of it.</p> <p>Verification requires that students must never lose (a) their blockchain wallet keys and (b) their records.</p> <p>A cost of decentralisation is that education providers lose their digital connection to alumni and cannot easily collect mobility statistics as credentials are used.</p>	<p>Blockchain confirms that the owner of cryptographic Key A issued a particular record to the owner of Key B at time T.</p> <p>It does not confirm that an education provider is who they claim to be.</p> <p>Comprehensive verification requires additional layers, sometimes involving verification via the issuer's website, which contradicts the blockchain paradigm.</p> <p>Blockchain depends 100% on cryptography and therefore the security of issuer's private keys are vital. Quantum computing may pose a threat to current blockchain algorithms ECDSA by 2027. Quantum Resistant Ledger technology is a work in progress.</p>	<p>It is easy to issue records onto a blockchain so participation is simple for education providers.</p> <p>Blockchain only handles verification of records – the exchange and archival of credentials require complementary solutions to be built.</p> <p>The participation burden shifts to the student as they now have responsibility of maintaining their records and keys in the long term.</p>
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Source: Adapted from Dowling, 2018

2. The key actors and communities

One of the actors contributing to the development of the global digital credential ecosystem is the Groningen Declaration Network (GDN). As noted by Sessa (personal communication, 2017), 'the immediate success of the Groningen Declaration Network is a sign of how much the education community is ready for digitalization'. Bai-Yun (personal communication, 2017) adds:

Perhaps the main initiative/network on a global level (HE) is the 'Groningen Declaration'. Their aim is to bring together key stakeholders in the 'Digital Student Data Ecosystem' and to allow digital student data portability – this includes the use of open standards and standard data exchange formats to allow interoperability of systems.

The GDN started in 2012, and by 2017 involved some 1,150 participants from across all six sectors in the model discussed above. These include digital student data repositories, the education sector, international membership organizations, (inter)national public bodies, policy influencers and consultancies, the IT world, immigration authorities, evaluation and recognition bodies, and employment and professional licensing boards (De Leeuw, 2017).

In Europe, there has been considerable progress towards creating digital learners' data ecosystems. For example, the European Commission is developing the European Area for Skills and Qualifications; the Bologna Follow-up Working Group is exploring the digitization of the Diploma Supplement; and other initiatives include the European Qualifications Framework for referencing qualifications, Europass, the Dutch Diploma Register, and the Erasmus *Without Paper* project. Other examples are the work of EMREX, the Spanish Electronic Diploma Supplement, eHEAR, the Diploma Registry in Norway, the Stork 2.0 eAcademia Pilot, the SPEEDE Server, the CINECA ESSE3 Diploma Supplement, Digitary, Ellucian eTranscript, Credential Solutions Electronic Transcript, Bestr Open Badge Platform, the Stanford Blockchain ledger and Parchment (Bai-Yun, 2017).

In the USA, the National Student Clearinghouse (NSC) supports electronic student data exchange. In China, CHESICC has pioneered student data digitization (AACRAO, 2014) and works closely with the Chinese Service Center for Scholarly Exchange (CSCSE), which is a public organization under Ministry of Education (MOE) of the People's Republic of China. In Australia, eQuals²³ is well under way (Whelan, personal communication, 2017). In the United Kingdom the HEAR Advisory Committee is the group responsible for oversight and governance of the Higher Education Achievement Record (HEAR). Members include the Higher Education Academy (HEA), the Centre for Recording Achievement, the Joint Information Systems Community (JISC) and UK NIC/NARIC. Platforms offering HEAR in the UK include GradIntel and Digitary (Bai-Yun, personal communication, 2017).

23 See www.myequals.edu.au

There are also Commonwealth of Learning (COL) initiatives in this area, including ‘the development of a curriculum for digital education leadership, the creation of off-grid, micro-servers which allow learners in regions with no connectivity to benefit from digital resources as well as an ongoing interest in the use of MOOCs for expanding the reach of post-secondary education’ (European Commission, 2017).

3. The Digitization of the Credentials Industry

While the open learning movement is largely premised on free and open educational resources, for-profit bodies are emerging in several domains of the ecosystem. These include bodies providing training, awarding, and also evaluation and more recently verification. There is evidence that a digital credentials industry is emerging: that is, a population of firms specialized in inventing and commercializing digital technology solutions aiming at supporting the digitization of credentials.

For example, Verifdiploma was established in 2001 in France in partnership with French higher education institutions (including universities, business schools and engineering schools) and also supported by French institutional bodies. Its services are available on the internet, to better inform recruiters on courses, to provide a degree verification service and to assist in the process of recruiting graduates and trainees. Many start-ups²⁴ in different parts of the world are actively leveraging blockchain technologies to integrate and build new institutional networks for authentication of credentials, and managing a new environment concerned with digital learning and mobility of learners. Other multinational companies such as Sony Global Education²⁵ are also investing to develop solutions that authenticate and control usage rights to educational data and handle these rights. These actors are part of a broader education industry that has emerged in recent years (Foray and Raffo, 2012).

The regulation of for-profit organizations operating in the ecosystem is strongly encouraged. However, despite the risks of ‘marketization’, the education industry could be an essential partner in any innovation strategy for the recognition of learning at global scale. For this purpose, instead of public education and training bodies viewing this industry just as a provider of goods and services, they could consider different relationships including research partnerships, internships/apprenticeships and collaboration over standards development.

4. Digital credential currency

The literature on digital credentialing is expanding, but much of it focuses on the potential to improve learning outcomes rather than labour market and social outcomes. Spaulding and Johnson (2016, p. 10) note that several research studies (for example Grant, 2014) focus on the effect of badges on motivation, and specifically their effectiveness in promoting participation and success within learning communities, and especially those online. The authors note that these studies suggest the effects of badges can depend critically on the type of badge, learner and context. However, few studies address the value of badges for employment, and there is no literature to date on the digital badge adoption rate among human resource professionals or hiring managers (Raish and Rimland, 2016). The most promising empirical research initiatives are in the USA. For example, several universities in the USA, including Georgetown University, and various employers and experts, have combined to initiate the ‘21st Century Skills Badging Challenge’ to design badges that are recognized as valuable by employers.²⁶

Raish and Rimland (2016) conducted an empirical online survey of 114 employers in different sectors (including IT, engineering, financing, manufacturing and logistics) in the USA to gauge perceptions of the use of digital badges to represent competencies that students have accumulated. The authors reported that when asked specifically whether employers would be interested in using a digital badge to evaluate the skills of recent college graduates, the response was promising, with 33 per cent of surveyed companies saying yes, 62 per cent saying ‘maybe’ and only 5 per cent saying no. According to the authors, the high percentage of respondents who said ‘maybe’ indicates that actions to raise awareness about digital badges would be necessary to improve adoption.

As proof that digital badges could eventually have value for employers and others outside of a learning or training context, Grant (2014, cited in Spaulding and Johnson, 2016, p. 10) offers examples of social media websites that have created ways for members to post evidence of their skills for potential employers. In a blog posting on the Institute for Credentialing Excellence website, Frank Catalano notes that digital badges are clearly gaining ground and increasingly being adopted by certain sectors such as manufacturing and software. Mozilla maintains a growing list of the organizations adopting digital badges.

Other anecdotal examples show that some companies value digital badges acquired by their employees, while others are engaging in partnership with training providers to give

24 See for example <https://educhain.io/>; www.bitdegree.org/en/token#top

25 See www.sonyged.com/2017/08/10/news/press-blockchain/

26 <http://eddesignlab.org/badgingchallenge/>

better currency to digital badges. For example, IBM has built a partnership with Northeastern University through its digital badge programme to ensure that certain IBM badges can be used towards Northeastern professional master's degree programmes (Jackson, 2018). Another example is Udacity, which launched the Nanodegree Plus programme with the promise that if learners earn a Nanodegree credential, Udacity will guarantee they obtain a job in the sector within six months of graduation, or refund 100 per cent of the tuition fee.²⁷

Another argument concerns employee engagement through earning digital credentials. In research regarding Microsoft certificates and badges, Janzow (2015) discovered that 90 per cent of learners who earn a Microsoft badge have claimed their badges. Those badges have been shared from Acclaim²⁸ over 3,500 times to LinkedIn, Facebook, Twitter and other online destinations. On average, each badge shared is viewed 2.4 times, indicating a strong interest from others in the badge earner's network who would like to learn more and verify the achievements represented by these badges.

Building badge currency may require efforts to build trust and demand among employers. More empirical research in different contexts and in specific industries would provide better understanding of the acceptance and currency of digital badges in labour markets.

5. Implications for the recognition of learning

A functional and agreed digital credential ecosystem has several implications for the recognition of learning internationally (Essa, personal communication, 2017). It will take time to mature, but significant progress has been made in the last few years. In the following section, we identify and elaborate on seven of the main implications.

Implication 1: Ubiquity and interoperability based on agreed standards

As Finkelstein and colleagues noted, 'The most basic and common expectation for any type of credential is standards' (quoted in Mah, 2016: 72). The development and implementation of qualifications frameworks has become closely associated with a range of standards. These include standards for qualification development, quality assurance, provisioning and the awarding of qualifications. Professional

standards have also become prevalent, and are actively being implemented across a range of professions internationally, notably in nursing, accounting and engineering, and also in teaching (also see Gallie and Keevy, 2014; Hofmeyr, 2017):

Teacher professional standards are broadly defined as the common standards, agreed upon by the teaching profession that characterize good teaching. They may serve a range of purposes, including the development of a professional teaching identity, informing the course development and accreditation of initial teacher education, as well as constituting the standards by which teachers can be held accountable. (Taylor and Robinson, 2017, p. 1)

Considering the digital credentials ecosystem mentioned earlier, standards for qualifications and related experience are increasingly being developed. The European Diploma Supplement (DS) is an important standard that promotes transparency, consistency and interoperability (European Commission, undated, p. 1):

The purpose of the supplement is to provide sufficient independent data to improve the international 'transparency' and fair academic and professional recognition of qualifications (diplomas, degrees, certificates etc.). It is designed to provide a description of the nature, level, context, content and status of the studies that were pursued and successfully completed by the individual named on the original qualification to which this supplement is appended. It should be free from any value judgements, equivalence statements or suggestions about recognition ...

Concerns about the reliability of current credential systems (Barabas and Schmidt, 2016) have resulted in a form of standards that are more oriented towards learning outcomes, and in digitization. The European Area of Recognition Project (EAR)²⁹ Manual is an excellent example. The Manual contains commonly agreed 'standards and guidelines on all aspects of the recognition of foreign qualifications and aims to provide the credential evaluators from the European National Information Centres network and National Academic Recognition and Information Centres network with a practical tool to assist them in their daily recognition work'.³⁰ An important feature of the EAR Manual is its aim to make the evaluation process more transparent to a wide range of stakeholders, including credential evaluators, higher education institutions (HEIs), students and policy officers.

Following the sequence of the digital ecosystem presented earlier in this paper, two additional sectors are also impacted

²⁷ <https://eu.udacity.com/nanodegree>

²⁸ Acclaim is Pearson's platform built on Mozilla's open-source badges framework. It provides organizations with a way to grant and verify badges, and students with a way to claim and share them.

²⁹ <http://eurorecognition.eu/>

³⁰ <http://ear.enic-naric.net/emanual/>, accessed 24 June 2017.

by standards. The first is consumers. Increasingly the legislation that protects the privacy of personal records is being tightened. The European Convention for the Protection of Individuals with Regard to the Processing of Personal Data (Council of Europe, 1981) has been in place for more than twenty years. Several other mechanisms have subsequently been put in place to protect personal data in Europe, with further tightening scheduled for 2018 (O'Reilly, personal communication, 2017). The USA, while federal in its approach, has the Financial Services Modernization (1999) Act which play a key role in this regard. In the United Kingdom there is the Data Protection Act (1998), while most other countries across the globe have followed suit.

The verification sector is perhaps less developed than the other four sectors in the digital ecosystem with regard to standards, although this is not entirely true. Digital standards, such as those discussed earlier in this paper, play a key role across all sectors, but even more so for verification. This is an area where a wide range of new for-profit and non-profit organizations are being established, while the government-led initiatives, many of which have been in place for several decades (as with EDGE and the NLRD), seem to be playing catch-up.

Of course, standards are not a silver bullet. As AACRAO noted,³¹ standards work best when there are established conventions, and also when they are developed at the right time: 'If standards are pursued too soon, they can inhibit innovation. Standards work best when there are established conventions' (AACRAO, 2014, p. 7). The role of the convenors in the digital credential ecosystems is key in this regard. International agencies such as UNESCO can play an important catalytic role, as has been demonstrated in the proposal for the development of world reference levels (Keevy and Chakroun, 2015) and the UNESCO/OECD guidelines for cross-border higher education (Vincent-Lancrin et al., 2015) to mention but two of many examples.

Digital standards have a cross-cutting function, impacting increasingly on all six elements of the digital credentials ecosystem. These standards are more technical in their design but have several characteristics that are similar to standards used for provisioning, awarding, quality assurance, evaluation and also verification. There are however differences in design and purpose, and the different standards should not be confused. The Mozilla Open Badge Standard (an open technical standard), also referred to as Open Badge Infrastructure (OBI), first released in 2013, stands out as an example of a standard that impacts across the digital credential ecosystem:

In terms of usability, badging platforms are rapidly evolving, enabling the issuing and display of the digital

credentials. OBI is emerging as a global standard framework for documenting and distributing badges. The OBI framework addresses issues of validity, authenticity, granularity, interoperability, flexibility and transferability and contains embedded metadata derived from this universal standard. (University of Southern California, 2013, in Ifenthaler et al., 2016, p. 61)

The important observation here is that the standards applicable to each of the elements, and also across the elements, of the digital credentials ecosystem are most successful when developed using the same ideology as the functional area they are being designed for. For example, quality assurance standards are firmly entrenched in the more traditional and centralized models broadly associated with the early generations of qualifications frameworks; evaluation standards are developed in the form of guidelines more appropriate for the credentials evaluation sector; while OBI emerges as a global standard for badges, championed by a non-profit body:

The [OBI] standard was a community-authored effort, as developers and other interested parties around the world came together to define the elements and characteristics of Open Badges, the ecosystem in which they would live, and how Open Badges would interoperate. (Ifenthaler et al., 2016, p. 56)

The challenge in the ecosystem lies in the often-competing ideologies that underpin the different type of standards. There are however some interesting 'crossover' standards developing. The notion of 'wiki standards' for qualifications is one example (see West and Keevy, 2008). The ENIC-NARIC guidelines for the recognition of 'non-traditional' learning and undocumented refugees, and potentially also for MOOCs and OERs, is another (Vincent-Lancrin, 2016). The work of the Humanities, Arts, Science and Technology Alliance and Collaboratory (HASTAC)³² is also contributing to interdisciplinary research impacting on teaching and learning. The PESC *Common Credential XML Data Standard* (involving Stanford University, the University of Maryland University College, the University of Southern California and AACRAO) is an example of a standard that applies across data transmission, document production and learning records.

The OBI standard can also be referred to as a crossover standard in that it is based on a recognition that the assessment of 'skills and learning outcomes [should be] consistently measurable and repeatable', but it challenges the dominant paradigm under which 'learning providers have traditionally relied on academic accreditation and reputation as validation of their learning outcomes and credentials':

³¹ See www.aacrao.org/

³² See www.hastac.org/about/history

Open badges enable new learning ecosystems, necessitating new methodologies for validation of learning providers, assessors, and learning outcomes through the recent introduction of endorsement. (Derryberry et al., 2013 in Ifenthaler et al., 2016, p. 222)

According to De Leeuw (2017), the trend will be that 'quality assurance agencies may not disappear, but the role of the institutions may become more pronounced'. He proposes that quality assurance agencies will need to make a shift from 'program accreditation to a more modular accreditation where individual credits can be checked for accreditation status', and that 'quality assurance agencies might want to take an interest in what it takes to assure that stacked, hybrid credits may lead to relevant, trusted learning outcomes'. In turn, this will result in accreditation becoming more visible – 'it could become part of a badge that certifies what went into an individual credit'.³³

There are several more examples where standards are being developed and are applicable to various functions in the digital credentials ecosystem. As noted by Pappano (2017), 'the explosion of credentialing has spurred a movement to bring structure to this unruly set of offerings'. A group called the Credential Transparency Initiative has been 'drafting a framework to enable anyone issuing a credential – from a badge to a Ph.D. – to let the world know what it stands for'. Pappano (2017) also notes the role of the Lumina Foundation, which has funded the Credential Engine (also see Lumina, 2016).

An example from India is worth noting. According to Vincent-Lancrin (2016), the Indian government passed new regulations for the recognition of MOOCs in 2016, following the launch of the Study Webs of Active Learning for Young Aspiring Minds (SWAYAM) MOOC platform in the same year. This new regulation differs from the more traditional standards associated with provisioning and quality assurance in that it 'allows accredited Indian higher education institutions and their affiliates to review all MOOCs posted on the platform and decide, according to their context, which ones they would like to offer (and recognize) in addition to their local offer' (Vincent-Lancrin, 2016, p. 15). Strong incentives are given to MOOC designers to use technology-based exams, while institutions can allow up to 20 per cent of courses offered by SWAYAM per semester in their undergraduate programmes. Music (2016, p. 19) expresses some concern with regard to the absence of standards for MOOCs: 'The absence of pedagogical and technological standards and a lack of government expertise and reactivity on this subject make this type of investment very risky.'

Standards of these varying types and purposes do have some common characteristics, although the emphasis differs. All standards attempt to enhance ubiquity and interoperability,

transparency and confidence, and authenticity. In order to achieve these goals, systems and structures need to be in place. This is where the longer-established players in the digital credentials ecosystem have an advantage. The relative inflexibility and drawn-out processes required to maintain and implement these systems is however a distinct disadvantage; this is not a limitation in the world of open learning, MOOCs, open degrees and digital badges. It is also important to realize that technology alone is not the answer: 'The "business" side of interoperability is just as important as the technical side. Socialization and organization of people and organizations must occur or align with the common goal of the technology' (Sessa, personal communication, 2017).

Implication 2: Protect the learner

The centrality of the learner (read user) in the digital credentials ecosystem has been mentioned several times. The privacy of personal records and associated legislation is key in this regard. Fraud prevention in an increasingly sophisticated technological environment requires more and more resources: 'technology alone is unlikely to provide an entire solution and may indeed result in an integrity arms race in which hackers revel in breaking warranting systems' (James et al., 2017, p. 50).

Risks are apparent in a number of areas (Bai-Yun, personal communication, 2017):

- Digital data security – ensuring that digital student data are secure in the digital environment in which they are held or issued. They must be secure in terms of preventing an individual's data from being extracted, and also preventing it from being altered.
- Human data security and accuracy – inevitably there is a human element to these systems, which is also potentially open to fraud and/or inaccuracy.
- There is the potential for fake repositories to be set up – either mimicking existing systems, or claiming to be a genuine qualification issuer when they are not.

The last point is important. The source of the data, be it in a sophisticated repository, relational database or another format, is one of the potential weak points in the digital credentials ecosystem. Even blockchain technology is susceptible to this risk. GDN has recognized the risk and established a Task Force for Verification Policies and Best Practices, which in turn has served as the inspiration for the establishment of the African Qualifications Verification Network (De Leeuw, personal communication, 2017). 'Hub and spoke models' that provide improved source authentication are being developed, including mobile versions of credentials (Sessa, personal communication, 2017). An important

33 See <http://ecahe.eu/supporting-student-mobility-groningen-declaration>

component of these new security mechanisms is to give the user the power to provide consent during a verification process (Shroff, personal communication, 2017).

Implication 3: Digital technologies can lead to more transparent recognition of skills and qualifications required by employers

It has been mentioned several times how digital technologies are providing the mechanism to implement instances of interoperability that to date have not been possible. The 3D CV is a case in point (Oliver, 2016b) as a mechanism that can transcend the limits of traditional credentials:

For example, I have a Bachelor's degree that's the same credential owned by many different people I went to school with. We all took very different pathways, but we all have the same degree, and there's no real or verified way for me to show that I specialized in these things or took these pathways. (Bowen and Thomas, 2014, p. 22)

According to Sessa (personal communication, 2017), it is however important to distinguish between 'business interoperability' and 'technical interoperability'. Sessa argues that while 'one vision of interoperability' may not be realistic on a global scale at present, there is the opportunity to achieve both business and technical interoperability on country and institutional levels.

An interesting theme emerging from the literature is the extent to which micro-credentials are 'seen to fill a gap between the stated and desired outcomes within a broad undergraduate degree and the skills, knowledge and competencies that employers are seeking in graduates' (Ifenthaler et al., 2016, p. 44). According to authors such as Finkelstein and colleagues (2013, in Ifenthaler et al., 2016) and Grant (2014, in Ifenthaler et al., 2016, p. 60), badges 'reveal unique learning pathways that facilitate the accomplishment of an individual's aspirations. In a very real sense, badges bring together two, often disparate, worlds – the world of education and the world of work.' The Mozilla Foundation concurs:

Open badges have become a form of shorthand to signal strong trends rippling through education and workforce sectors, including 21st century skills and competencies, authentic assessments, networked technologies, learner voice and choice, and data ownership. Often, when organizations turn to badges as a new practice, they invoke complex design work that threads together many strands of these different trends. (Mozilla, 2016, p. 5)

The fact that micro-credentials are more flexible and responsive make them very useful in designing flexible pathways that appeal to employers, compared with traditional or macro-credentials and their more static pathways which are often not well understood by employers. This tension

between the two different forms of credentialing is leading to improved transparency through the development of a common language, but there is still a long way to go. As Lumina points out, we still have a 'fragmented, dysfunctional credentialing system that's out of sync with 21st century needs' (Lumina, 2016, p. 2).

The ability of digital credentials to represent and measure twenty-first-century skills is also a recurring theme in the research. According to Bowen and Thomas (2014, p. 25), '[we] often hear that what employers really value are the broad skills embedded within a college degree – skills like communication, critical thinking, teamwork, leadership and problem solving – that aren't apparent on a transcript or resume. Badges may play a role in conveying acquisition of these types of competencies.'

Implication 4: Stacking may not always lead to coherent qualifications

Credit transfer, credit accumulation and a variety of other mechanisms have been reasonably well developed in most qualifications frameworks, at least in theory, and in many instances also in practice. Part-qualifications, such as unit standards and national vocational qualifications (NVQs), have constituted an important part of this landscape, but have also been strongly contested, mostly because of concerns about the fragmentation of learning they could result in. With the introduction of micro-credentials, and the associated digital delivery modes, the combination of credits takes on a whole new form. Referred as 'stacking', 'badges and certificates (earned for completing a course) as well as licenses and certifications (which require an exam and must be renewed)' (Pappano, 2017) can be combined in various forms, which many may argue will result in even greater fragmentation of knowledge and in combinations that may not hold together logically. The familiarity of the public, and especially of employers, with such combinations may also limit employability: 'Like a real-life game of Pokémon, people are collecting and stacking them – mixing, sequencing or combining – to show off their powers' (Pappano, 2017).

This is the challenge to the digital credentials ecosystem. Stacking is so flexible that it 'is likely to challenge and disrupt existing credentialing mechanisms and institutions' (Ifenthaler et al., 2016, p. 61). At the most extreme is a situation where 'a degree would just be an aggregation of MOOC credits, of "nano-credentials"' (Vincent-Lancrin, 2016, p. 22). If disciplines are treated in this manner, the hierarchies of knowledge, skills and competences (see Keevy and Chakroun, 2015), become obsolete, and deepening of understanding, application and evaluation becomes a hit-and-miss affair. Of course, we need to acknowledge that many existing macro-credentials have not necessarily been able to achieve such cohesion either (Oliver, 2016b).

The micro version of MOOCs, known as small private online courses (SPOCs), represents a good example of the extreme implication of digital credentials for the recognition of learning. De Leeuw (2017) quotes Senator Bruijn speaking in the Dutch Senate in this regard:

SPOCs may change the game. They may do away with quality assured programs of study, since students may start to stack individual credits in hybrid ways, by combining traditional lectures, MOOCs, and SPOCs that no longer need to derive from just one source but basically can be elected by the student himself. This could sound the end of final degree examinations; instead, students may have to apply for tests that are HEI agnostic and agnostic as to the mode of delivery. If SPOCs could be taken to represent a generalized trend towards customized, individualized modes of delivery and certification, this may necessitate a discussion about core concepts such as institution, credentials and degrees. And it may necessitate a discussion on the role of national government authorities when it comes to accreditation and to funding (of institutions and of students).

It is in the interface between micro and macro-credentials that most opportunity resides. Platforms such as EdX have been developed for this purpose and allow for credit exchange between the two approaches. Barabas and Schmidt (2016, p. 6) are of the view that macro (meta)-credentials that are designed on digital and open principles can in fact 'knit together a more complete and detailed profile of a learner's experiences and competencies'. By drawing on the strengths of micro-credentials, such qualifications can be more dynamic and contain much richer forms of information.

Implication 5: Quality assurance and governance systems need to be more responsive

It has become obvious during the development of this paper that the digital credentials ecosystem is made up of a combination of traditional (better established) systems and flexible and dynamic (much less regulated and new) systems. This is a natural situation and a common characteristic of most complex systems. The challenge for the recognition of learning is that the pace of development, and also the point of departure, of these two aspects is radically different. This results in increased consumer vulnerability. The varying quality of MOOCs is an example in this regard (Music, 2016). The role of conveners to assist nations and regions to develop 'comprehensive frameworks for co-ordinating various initiatives at the international level' in order to address the 'diversity and unevenness of the quality assurance and accreditation systems at the national level' becomes more

important (Vincent-Lancrin et al., 2015, pp. 14–15). Sessa comments that conveners can facilitate:

a common vision, like a Global Student Bill of Rights, [which] might provide minimum guiding principles so that going forward, all countries, institutions, providers and vendors at least have a small blue print on how development might align in the future, rather than continuing uninformed and disparate. (Sessa, personal communication, 2017)

There are examples of quality assurance and governance systems being adapted to accommodate digital credentials, but these are limited to Europe, the USA and to some extent Australia. Examples include the European Transfer and Accumulation System (ECTS) and the European Credit System for Vocational Education and Training (ECVET), and also the new generation of qualifications frameworks being developed in the USA (Rein, 2011). New types agency are also emerging. James and colleagues (2017, p. 45) recognize the work of the Lumina Foundation, and also the IMS Global Consortium Digital Credentialing initiative which is 'developing standards for metadata to support analytics and the interoperability in definition of badges'. Linking badges to competency-based frameworks is one option, but this is not straightforward (Ifenthaler et al., 2016).

Another open method of cooperation and quality assurance is the setting-up of Open Badges Communities,³⁴ including Open Badges Community Councils and the Badge Alliance Standard Working Group.

Implication 6: Enabling the recognition of prior learning

The last implication of digital credentials for the recognition of learning we would like to highlight in our paper is the extent to which recognition of prior learning (RPL) can be facilitated. Just as digital technologies have made it possible to think about representation in much more concrete terms, so too is it possible to consider new forms of RPL.

According to the Open Badge Network and the European Commission (2016), many consumers are interested in badges as a means to recognize non-formal learning. The challenge is that current RPL approaches are mostly not based on open learning principles, 'that is, through MOOCs, open web-based learning or other open educational resources, but rather through work experience' (Vincent-Lancrin, 2016, p. 13). This is despite the fact that MOOCs meet the definition of non-formal learning (Music, 2016). Because MOOCs generally follow academic conventions they are particularly useful for RPL processes. The challenge arises when the MOOCs of other institutions have to be recognized, as this 'can raise

34 <https://openbadges.org/community/>

reputational, legal and financial issues' (Vincent-Lancrin, 2016, p. 14).

Digital badges in particular enable 'an alternate credentialing system that supports pathways for, recognition of prior learning, and portability outside the institution they were achieved, linking the worlds of education, work and community in meaningful ways' (Ifenthaler et al., 2016: 55). The decoupling of learning and assessment inherent in most digital credentials make them very suitable for forms of assessment and recognition that can be done at a later stage, not necessarily by the same institution where the learning took place (James et al., 2017).

Implication 7: Ensure effective government support and multi-stakeholder cooperation

The Broad Band Commission Working Group on Education Report (2017, p. 5) considers that

government and state actors play a leading role in setting the conditions for sustainable and equitable provision of digital skills development. Governments should continuously enhance their digital capacities to establish and enable inclusive and equitable digital skills provision. This can be accomplished by developing regulatory frameworks, planning and coordinating national policies and strategies, creating and managing partnerships, evaluating outcomes, championing digital rights and safety, and promoting gender equality and inclusion.

The relative homogeneity in Europe, and also in the USA and to some extent Australasia and China, has made it possible for innovations related to digital credentials to flourish.

The establishment of open or e-government presents another opportunity to further develop digital credentials platforms at country levels. India stands out as a country that is taking this seriously (Lesperance and Balaji, personal communication, 2017). According to Shroff (personal communication, 2017), the Government of India has decided to digitize records of all academic institutions from 2017–18. This includes awards from universities, school boards, and autonomous institutions under various ministries. A subsidiary of Central Depository Services Ltd (CDSL) has been chosen to provide an end-to-end solution. The Middle East and North Africa (MENA) also stands out as a region that is making considerable progress with digital government strategies (OECD, 2017).

Small states are however often not as advanced, nor are many parts of the developing world. Pronounced inequalities and disparities exist in access to online educational resources.

Indeed, alongside all of the potential benefits and progress outlined in previous chapters, there is a growing body of evidence suggesting that people's ability to engage with

digital technology is differentiated along a number of lines, notably socio-economic status, race, gender, geography, age and educational background (ITU, 2017a). The 'digital divide' is a major challenge. Digital inequalities continue to be well documented, and in many instances divides across lines of geography, gender, age, physical abilities, socio-economic status, language and educational attainment are growing. Over half of the world's population (some 3.9 billion people) remain unable to connect regularly to the internet (ITU, 2017b). The World Bank *World Development Report* (2016) notes that those unable to access the internet include disproportionate numbers of women and girls, and people living in remote and rural areas, with low levels of education and living on low incomes. For instance, recent ITU (2017b) data suggests that males are now 12 per cent more likely to make use of the internet than females — a figure that rises to 25 per cent in Africa.

As mentioned earlier, several reports (see Schmida et al., 2017; World Bank, 2016) have identified key barriers to accessing the internet, including lack of infrastructure, low incomes and lack of affordability, limited user capabilities, including basic literacy and digital literacy, and the limited incentives for access, including lack of awareness, little relevant content, and issues of cultural or social acceptance. Beyond simple technological access, capacity gaps exist. The Broad Band Commission Working Group on Education Report (2017) considers that the knowledge, skills and competencies required to access and analyse information and best utilize it in a given context affect to what extent 'digital dividends' can be reaped, or to what extent the digital divide can be magnified. Usually, the harvest is greatest among groups that are already privileged. Those who are marginalized by their gender, ethnicity, geographical location or economic status tend to be left behind in participating in our digital societies and digital-enabled transformation.

Reconciling these gaps will require more than technology alone. Holistic approaches – encompassing policy, implementation, funding and partnership – are needed to ensure that all learners have opportunities to cultivate relevant skills and obtain access to digital credentials. In sum, consideration of the unique challenges in developing countries, particularly the least developed countries, will be instrumental to the goals of access to digital credentials for all.

Chapter 4: Implications for World Reference Levels

1. Progress and remaining challenges

As mentioned in the Introduction, the development of a set of world reference levels (WRLs) is driving this work on the digitization of credentials. The WRLs process has acted as a catalyst to create a global platform for discussing the recognition of qualifications, as well as developing a common language and shared understanding of the challenges and solutions for the recognition of learning internationally (see Chakroun and Ananiadou, 2017, for a detailed account regarding progress). This was perhaps somewhat ahead of its time, but had the involvement of the qualifications framework community,³⁵ and now also has a serious engagement with the ecosystem of digital credentials.

Since 2013, UNESCO has made progress in the conceptual development of the proposed WRLs by undertaking several research studies in collaboration with international experts in the field. Studies carried out include a comparative study of qualifications across borders, an analysis of level descriptors, and a study on the way qualifications frameworks relate to each other, with a focus on referencing processes.

Hart (2017) summarizes the purpose and use of WRLs as follows:

WRLs are intended to provide a common language to be used as a basis for comparing individuals' capacities. They will generate internationally comparable information. They are not intended to set new standards or norms for qualifications or frameworks. They are based on, and intended to be compatible with, a range of existing structures, instruments and approaches (including the validation of non-formal and informal learning) in all fields of learning and achievement. They are not intended to set compliancy regulations for qualifications, to bring qualifications into a single register or database, or to create rules for the recognition of qualifications, competences and capabilities. They could, however, be used for developing shared understandings of

qualifications, establishing local databases, or agreeing recognition protocols.

WRLs will produce usefully detailed 'translations' of required or certificated capacities. They may assist with, but should not interfere with, existing or planned agreements on recognition and mobility. They might be used along with other globally agreed principles on procedures for the recognition of qualifications, competences and capabilities.

In addition to the development of a World Reference Levels framework and in the context of this area of work, UNESCO in cooperation with Cedefop (the European Centre for the Development of Vocational Training) and the European Training Foundation (ETF) carried out a pilot comparison of four TVET qualifications in twenty-six countries. The purpose was to gain insight into the similarities and differences between countries in the content and profile of their qualifications. The key findings were that countries describe and present their qualifications in different ways. While most countries use some form of learning outcomes approach, the length and format of the documents and the terminology used vary considerably. This makes it difficult to capture precisely and compare the intentions and priorities expressed by the qualifications (Bjornavold and Chakroun, 2017).

The Shanghai recommendations addressed this issue by suggesting establishing external reference points. The research carried out by UNESCO in cooperation with Cedefop and ETF³⁶ used two main external reference points to compare qualifications: a draft version of the European classification of skills, competences, occupations and qualifications (ESCO), and the US O*NET classification.³⁷ World Skills standard specifications (WSSS)³⁸ were also used to further test the validity of the findings, pointing to yet another possible external reference point to be used for comparisons (Cedefop, 2016). While the study demonstrated that systematic comparison of national qualifications is indeed feasible, the approach proved time and resource-demanding, making it difficult and costly to repeat for other qualifications and countries. The study furthermore demonstrates that data on the content and profile of qualifications can be extracted from

35 Including the ASEAN Qualifications Reference framework (ARQF), European Qualifications Framework (EQF), Caribbean Regional Qualification Framework (CRQF), Pacific Qualifications Framework (PQF), Teaching Quality Framework (TQF) and South African Development Community Regional Qualifications Framework (SADC RQF).

36 The study is available at UNESCO (unpublished)

37 O*Net was used as a reference point for the 2009 BMBF study, covering four vocational education and training qualifications.

38 www.worldskills.org/what/education-and-training/wsss/

a variety of sources, notably qualification profiles/standards, occupation standards, curricula and assessment specifications (Bjornavold and Chakroun, 2017). It also identified the most frequently used categories for describing qualifications, which could be a starting point for developing a common template for describing qualifications internationally (Chakroun and Ananiadou, 2017).

2. Implications of digitization

Hart suggests that WRLs will be accompanied by ‘guidance’ on how they can be used, and also that this ‘analogue’ approach might be supplemented by digital tools to support the matching process’. Ideally, according to Hart (2017), ‘such tools might be extended to the point where WRLs would become fully digital’. However, to achieve this goal, the WRL ecosystem should include functions to continuously capture, connect, archive and share global metadata about credentials, credentialing organizations, quality assurance organizations and competency frameworks, and additional metadata as needed to support the cross-border recognition of qualifications.

As part of the work on WRLs, UNESCO and its partners intend to propose a vision to reach a common international approach where all aspects of a person’s learning are electronically documented, authenticated and can be accessed at any time and anywhere, shared and amended by the owner or by an authorized party.

In Chapter 3 we outlined the key implications of a functional and agreed digital credentials ecosystem for the recognition of learning internationally. Considered at a global scale, the twin issues to be addressed are whether digital technologies can support access, processing and structuring of credentials data at global scale; and whether they can provide the reliable data required for an international repository of quality-assured providers and credentials.

To further ensure progress at global scale, efforts have to be directed towards gathering and making accessible at scale credentialing information from all types of source; developing methodologies for comparing credentials; addressing the multilingual challenges involved in processing credentialing data at international levels; and creating and promoting an international label for ‘open learning records’.

For this to succeed, it is crucial to bring together the insights gathered from UNESCO’s and other partners’ initiatives. Four initiatives are critical. They address in complementary ways the four key issues mentioned above that prevent major progress in trusting and recognizing skills and credentials at global scale. These initiatives are presented in Box 1.

Box 1 Promising initiatives

Gathering and making accessible at scale credentialing information from all types of sources

Lumina Foundation: Credential Engine

The Lumina Foundation (www.luminafoundation.org/) launched in December 2017 a centralized credential data platform called the Credential Registry, a common credentialing language for credential evaluation, a digital application to search for credentialing information, and an Application Programming Interface (API) tool to allow organizations to continuously upload up-to-date information to the Registry. The Credential Engine aims at gathering credentialing information from all types of source – including degrees, certificates, badges, apprenticeships, licences, micro-credentials, and PhDs – drastically improving credential transparency.

The Credential Engine includes these features:

- Common language: New metadata called the Credential Transparency Description Language (CTDL) will be used to describe key features of credentials.
- Open-licensed registry: This first-of-its-kind, voluntary registry will share comparable information from credentialing organizations about their range of credentials and how they relate to each other, to help people create learning pathways.
- Shareable data: Customized apps can be built for students, companies and other interested parties, making the massive database even more useful.

Developing methodologies for comparing credentials

Cedefop: Comparing Vocational Education and Training Qualifications: Towards a European Comparative Methodology

This Cedefop study (www.cedefop.europa.eu/en/about-cedefop/public-procurement/comparing-vocational-education-and-training-qualifications-towards) will contribute to the development of methodologies allowing for systematic and regular international comparisons of vocational education and training qualifications. This is why comparisons of qualifications are not only about analysing the qualifications as such, but require a focus on how and whether these qualifications match the requirements of the labour market and society.

The initiative aims at achieving the following results:

- Explore and test appropriate reference points for comparison, in particular by analysing the strengths and

weaknesses of ESCO, O*Net and World Skills Standard Specifications.

- Explore how to more efficiently gather and analyse qualification data, notably by exploring emerging national databases as well as technologies for 'automated' data gathering.
- Explore and test methods for gathering data on the match/mismatch between qualifications and labour market requirements.

Addressing the multilingual challenges involved in processing credentialing data at international levels

The Jožef Stefan Institute (JSI) in Ljubljana (Slovenia), UNESCO Chair on Open Technologies for OER and Open Learning: ExplorEdu (<http://unesco.ijs.si/project/explorededu/>)

ExplorEdu is a system of freely available web services and mobile applications for automatic identification, capture, enrichment, editing, in-depth analysis and intelligent use of freely available educational resources, existing web and mobile educational services, studies and results of research projects, lesson plans, rules and legislation in Slovenia, Europe and the world.

ExplorEdu is aiming to establish an online service for automatic acquisition, structuring and analysis of all relevant data and information, open education, and mobile clients for contextual view, change-oriented and semi-automatic creation of freely available training modules for the needs of the target groups of teachers, trainers, learners and researchers.

ExplorEdu web services will constitute the core technology that will be used in existing information services such as SIO and ScienceAtlas, and the OpeningupSlovenia portal, as well as the base service for the UNESCO Chair of open technologies and open learning.

The ExplorEdu mobile application will serve as a basis for contextual and targeted investigation and semi-automatic structuring of open educational modules.

The baseline technologies and solutions will be based on existing open services that have been developed at JSI and that are part of applications such as <http://newsfeed.ijs.si>, <http://enrycher.ijs.si>, <http://eventregistry.org>, <http://searchpoint.ijs.si>, <http://scienceatlas.si>, iDiversiNews (App Store) and <http://videlectures.net>.

ExplorEdu will:

- allow open access to all collected freely available educational resources of different modalities (text, numeric, video, graphs, structured knowledge);

- offer a range of innovative services based on semantic technologies for comprehensive empirical analysis of the Slovenian open educational resources as an in-depth search for text and video analysis of developments in the Slovenian educational environment, including competence charts, graphs, collaborations, prediction, trends and simulations, as well as tools for acquisition, assembly, reuse and optimization of educational content;
- allow bidirectional data transfers between existing services such as the SIO database (with local educational data);
- enable integration between databases, states' initiatives, OpeningupSlovenia, VideoLectures.Net, scienceatlas.si and ist-world.org;
- allow open access to other services such as web portals, the SIO portal, educational institutions and portal development departments, with the aim of promoting wider Slovenian open educational content.

Creating and promoting an international label for 'open learning records'

The UNESCO General Conference in its 39th session decided to prepare a Recommendation for Future International Collaboration in the field of Open Educational Resources (OER) for submission to the next session of the General Conference, which will take place in 2019. This decision was adopted with an overall support of all UNESCO Member States. The debate proved that there is enormous interest in shifting open education and OER to a higher level. This Recommendation is a direct follow-up to the Second International Congress on OER, which was held in Ljubljana in 2017.

The Recommendation could consider, among others, the creation and promotion of an international label for 'open learning records'.

Source: Authors

Chapter 5: Conclusion and Recommendations

This report has covered a wide spectrum of factors associated with the digitization of credentials. What is abundantly clear is that any form of digital credential ecosystem comprises a combination of more traditional and better-developed systems, and more disruptive and for the most part less-developed systems. This interplay allows for innovation, but also creates a vacuum in which the learner/user is vulnerable.

Based on the review of digital credentials, we have noted at least seven key implications for the recognition of learning:

- 1 Ubiquity and interoperability should be based on agreed standards.
- 2 There is no doubt that digitization is making representation a closer reality. However, we need to protect learners (users) within the ecosystem.
- 3 Digital technologies can lead to more transparent recognition of skills and qualifications required by employers, including transversal skills.
- 4 There is an inherent risk associated with open degrees and micro-credentials that the ‘whole will not be greater than the sum of the parts’. Stated differently, the risk is that the stacking to form a macro-credential will not be conceptually sound and as a result, it will not be recognizable by employers. Hence stacking (the combination of micro-credentials) may not always lead to coherent qualifications.
- 5 There exists an interesting duality between traditional (macro-) degrees and the way they are offered, leading to formal certification, and micro-credentials, largely offered through MOOCs and represented by open badges, leading to non-formal or partial certification. Quality assurance and governance systems need to be more responsive to these dynamics.
- 6 Digital credentials have the potential to enable the recognition of prior learning.
- 7 Government support and multi-stakeholder cooperation need to be effective. The report highlights the importance of international cooperation.

The report also identified implications for the work on WRLs. It suggests that digitization of credentials affects the WRL ecosystem and functions. It calls for progress on a set of issues to further ensure development at a global scale, and suggests that efforts have to be directed towards gathering and making

accessible at scale credentialing information from all types of source; developing methodologies for comparing credentials; addressing the multilingual challenges involved in processing credentialing data at international levels; and creating and promoting an international label for ‘open learning records’.

We recognize that a weakness in the research was the lack of more direct engagement with employers to determine how they regard micro-credentials, including more empirical studies to support such views. A key future action, following from this paper, is to undertake a set of case studies on how employers use digital credentials in concrete ways, and how their recruitment and management practices have been affected by these developments. Two other areas that need to be explored further are the extent to which digital credentials are impacting on skills recognition for refugees and migrants (see UNESCO, 2018 and ILO, 2018), and how digital credentials can help to meet the SDGs and foster more inclusive access to skills training, particularly for the most vulnerable.³⁹

As countries, regional economic communities and the international community struggle to develop a unified strategy to ensure better and fair recognition of skills and certification across borders, the report has tried to identify some of the ways in which this community can take actions with the greatest impact. At the same time, the reports conclude that taking advantage of technological progress and innovations linked to recognition of learning and learners’ records cannot progress without commonly agreed digital metadata standards for such records. While more research, consultation and discussion are required, it is suggested that UNESCO consider adopting in partnership with other organizations a chart regarding ‘open learners’ records’ in the context of the forthcoming recommendation on OERs. Alternatively, there could be a separate UNESCO recommendation or guidelines which enshrine the principles of public goods, rights-based approaches, recipient ownership and security, vendor independence and decentralization.

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39 D. Poschmann, personal correspondence, March 2018.

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