Digital Credentials in Higher Education Institutions: A Literature Review

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Abstract. Digitalization is an essential driver for change, also influencing universities in their operation. However, the graduation certificate is still paper-based and does not fit employers' digitized recruitment processes. Digitizing the graduation certificate is overdue to align with the digitized processes of employers and universities. However, there is only a few research on that issue. This paper aims to conduct a systematic literature analysis. Therefore, we investigated 147 articles in the context of research on digital credentials. The results show that, although there is an increasing interest in this research area, the research community lacks a unique understanding of digital credentials. The paper gives an overview of research made so far and contributes to identifying research gaps in the context of digital credentials.

Keywords: Digital credentials, digital badges, higher education institutions

1 Introduction

Digitalization is changing almost every area of life. Also, it affects universities in their role as a teaching and researching organization [1]. Universities use new technologies to modify their processes; for example, developing simulated learning environments via virtual reality [2], video archives of lectures, and massive open online courses (MOOC) supporting the student's ability to learn independently regarding time and place [1]. The corona pandemic pushed the digitalization of education further. However, graduation certificates issued by German higher education institutions (HEI) are still paper-based leading to several inefficiencies. The paper-based graduation certificate does not fit the most digitized recruitment processes of employers, leading to the certificate owner's expenditures to digitalize the certificate, so automated processing of the contents is not possible by employers. Besides, the employer has to struggle with trust issues, as it is easy to falsify paper-based graduation certificates. Digitizing the graduation certificate could increase efficiency and is overdue to align with the digitized recruitment processes.

Digital credentials are "the digital equivalent of paper documents, plastic tokens, and other tangible objects issued by trusted parties" [3]. Additionally, for data protection and privacy, they provide the possibility to hide certain information for the accessing recipient [3]. We have two main reasons to analyze digital credentials in detail. First, using digital credentials for digitizing graduation certificates could solve the caused issues of paper-based certificates such as data protection and time for authentication

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and validation. Second, digital credentials in the context of HEIs are relatively new and little-discussed yet [4]. In addition to that, prior research lacks an overview of that research field, building the basis for further studies. The article provides a basis for further research on digital credentials in higher education. Thus, we follow the research question: *What is the current state of the art of research on digital credentials in the context of higher education institutions?*

The paper conducts a systematic literature review analyzing 147 papers in the context of digital credentials in higher education institutions. It contributes to evaluating the relevance of digital credentials as a research area in the context of higher education, the creation of a status quo of research in that field, and the identification of research gaps.

We structure the study as follows: In the section Terms and Related Work, we give a general understanding of digital credentials and their potential in the context of HEIs. Afterward, we describe the methodology approach and present in the section Results our findings. We discuss the findings in the section Discussion. Finally, we give an outlook for future research and state the paper's limitations in the section Conclusion.

2 Terms and Related Work

Digital credentials represent "the digital equivalent of paper documents, plastic tokens, and other tangible objects issued by trusted parties" [3]. In education, digital credentials enable the holder to decide which information when and how revealed to others. Additionally, digital credentials provide greater security than paper-based documents [3]. In conclusion, digital credentials can change the way of issuing and managing graduation certificates from paper-based to digitized.

Digital badges emerged in the educational area as another trend [5]. According to [6], a digital badge "is a representation of an accomplishment, interest or affiliation that is visual, available online, and contains metadata including links that help explain the context, meaning, process and result of an activity." Digital badges have their origin in games, where the user gets badges by reaching performance benchmarks. Within education, they tend to motivate learners by providing an incentive to identify the progress in learning and support credential management [6]. Digital badges contain metadata referring to the skills and knowledge earned, like information about the issuer, knowledge achieved, activities are undertaken to achieve the badge, and quality of the experiences and performances [6]. Digital badges are used for certification: formal, non-formal, and in-formal qualifications, but on a very granular level, not yet very widespread.

"**Micro-credentials** are a virtual, portable way of cashing in on acquired learning, especially granular skills" [7]. They are mini-certifications in study programs and enable students to represent the knowledge achieved through successfully participating in a module or course. To earn these micro-credentials, a student must submit evidence of their learning process, which is evaluated afterward. Employers can use this

achievement accreditation for evaluating their new hires [8]. Therefore, the focus lies on the content and not the certificate replacement.

Alternative credentials represent learning certifications of non-credit programs and therefore are no digitization of traditional transcripts. These digital credentials describe an individual's skills and knowledge and complement the traditional transcript [9]. As a result, alternative credentials support the concept of lifelong learning.

Technical applications of digital credentials are found in the area of platforms. One application consists of a centralized server platform [10]; other platforms use the blockchain to manage digital credentials [11-15]. Platforms using the open-source Ethereum infrastructure have been implemented [12, 14] and solutions with the Bitcoin blockchain as the underlying infrastructure [11].

3 Methodological Approach

In order to assess the current state of the art on digital credentials in HEIs, we executed a systematic literature analysis based on [16] and [17]. The search for relevant literature covered the databases: Scopus, EBSCOHost, ACM Digital Library, ScienceDirect, IEEE Explore, and AISeL. To identify appropriate literature, we choose an iterative approach concerning the hit rate. As the goal is to derive the current status of research on digital credentials, we considered 'Digital Credentials' as a relevant keyword for the query in a five-step approach. Also, getting the newest word stem in this specific field [4]. Figure 1 illustrates the applied methodology.

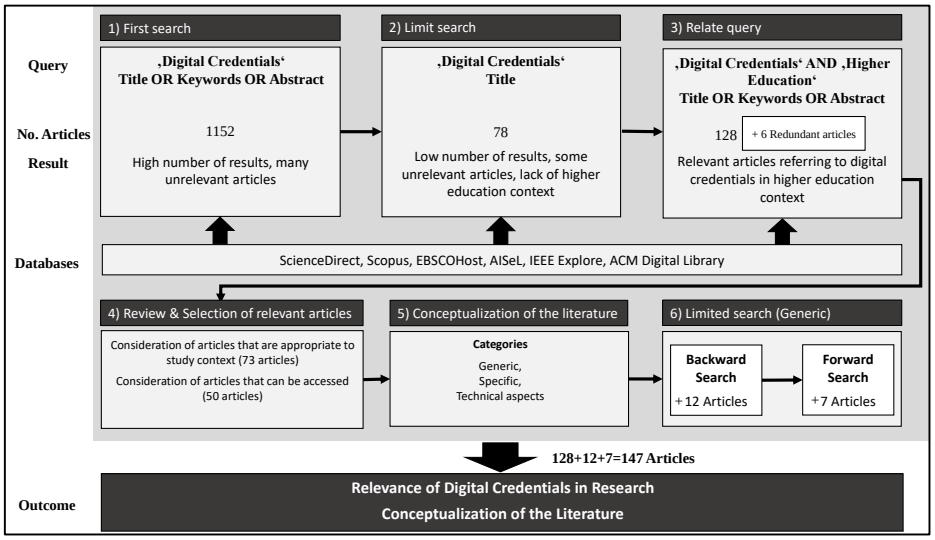

Figure 1: Literature Review Approach

First, we searched for this within title, keywords, and abstract (result: hit rate 1152).

Second, to enclose the found literature, the keyword was searched only in the titles (result: hit rate 78). However, many of the found paper did not relate to the topic of digital credentials in HEIs. The fact that digital credentials are a general term used in different contexts causes less relevance. [3] defined digital credentials as "the digital equivalent of paper documents, plastic tokens, and other tangible objects issued by trusted parties."

Third, to further specify the query for this paper's research context, it was useful to add the keyword 'Higher Education' to the query. The search for 'Digital Credentials' and 'Higher Education' within title, keywords, and abstract resulted in 128 articles. We reviewed the articles and selected contributions that are relevant to the study. To define relevant articles, we elaborated if the studies are referring to the defined research context, resulting in 73 appropriate contributions. Among these 73 contributions, 23 could not be accessed. As a result, we included studies that could not be accessed in the literature's conceptualization but excluded them from further investigations.

Fourth, we categorized the digital credentials into generic, specific, technical aspects. Moreover, we documented the usage of terms in the context of digital credentials. To gather additional literature, we conducted a forward and backward search focusing on the category digital credentials generic, according to [16]. The forward and backward search revealed 19 additional contributions for investigation. In total, we reviewed 147 articles, whereby we used 73 articles for the conceptualization of the literature and further investigated 69 contributions according to their contents.

4 Results

We conceptualized 73 studies, and most contributions discuss digital badges (61). The other categories occur with similar frequency: generic (11), alternative credentials (4), micro-credentials (6), and technical application (6). Table 1 presents the identified papers and the number of papers assigned to a specific category.

Author(s)	Digital Credentials				TAp
	Gen	Specific			
		DBa	ACr	MCr	
AACSB [18], Bull [19]			X		
Matkin [9], Farmer and West [20]		X	X		
Swan [21]					X
Jirgensons and Kapenieks [22]		X			X
Kamišalić, Turkanović, Mrdović and Heričko [23], Hölbl, Kamisalić, Turkanović, Kompara, Podgorelec and Herićko [12], Arenas and Fernandez [24], Newswire [25], Newswire [26]	X				X
Connolly [27]	X	X			

Author(s)	Digital Credentials				TAp
	Gen	Specific			
		DBa	ACr	MCr	
Rimland and Raish [7], Lim, Nair, Keppell, Hassan and Ayub [8], Lewis and Lodge [28], [29], LaMagna [30]		X		X	
Friedler [31]				X	
Parks, Parrish and Taylor [32], Newswire [33], Newswire [34], Norman [35]	X				
Newby and Cheng [36], Cheng, Richardson and Newby [37], Borras-Gene [38], Lim, Nair, Keppell, Hassan and Ayub [8], Friedler [31], Carey and Stefaniak [39], Cheng, Watson and Newby [40], Beattie and Jones [41], Hartnett [42], Shields and Chugh [43], Crafford and Matthee [44], Abramovich [45], Hickey [46], Wilson, Gasell, Ozyer and Scrogan [47], Hamson-Utley and Heyman [48], Olneck [49], McDaniel and Fanfarelli [50], Gamrat and Zimmerman [51], Elliott, Clayton and Iwata [52], Ahn, Pellicone and Butler [53], Rughinis [54], Newswire [55], Rimland and Raish [56], Bradley [57], Alliance for Excellent Education and Mozilla [58], Eaton, Rennie Center for Education and Policy [59], Newswire [60], Hartman and Andzulis [61], DiSalvio [62], Sullivan [63], Watters [5], Fanfarelli, Vie and McDaniel [64], Buchem [65], Gibson, Coleman and Irving [66], Brauer and Siklander [67], Virkus [68], LaMagna [30], Peck, Bowen, Rimland and Oberdick [69], Fedock, Kebritchi, Sanders and Holland [70], Ellis, Nunn and Avella [71], Ifenthaler, West, Flintoff, Lodge, Gibson, Beattie, Irving, Lewis, Coleman and Lockley [72], Mah, Bellin-Mularski and Ifenthaler [73], Diamond and Gonzalez [74], Carey [75], Balci, Secaur and Morris [76]		X			
Sum of Articles	**10**	**60**	**4**	**6**	**7**

Table 1: Conceptualization of Contributions, Gen = Generic, DBa = Digital Badges, ACr = Alternative Credentials, MCr = Micro-Credentials, TAp = Technical Application

4.1 Technical Application

The found contributions discuss technical applications referring to blockchain implementations in the context of digital credentials, digital badges, and higher education in general. [12, 22-24] Blockchain characteristics, features, and implementation challenges of the EduCTX project are described [12, 23]. A categorization stated by [23] assigns blockchain applications into institution-centric approaches and student-centric approaches. While institution-centric applications focus on simplifying the higher education institution's processes, the student-centric category creates benefits from the 'student's perspective [23].

4.2 Specific Digital Credentials

Digital Badges

The usage of the specific term Digital Credentials relates to the mass of found articles in the context of Digital Badges. However, there are several different understandings of the characteristics and specifications of digital badges:

(1) as micro-credentials [7, 8, 22, 36, 47, 51, 52, 57, 59],
(2) as micro-credentials and micro-learning platform [37],
(3) as a type of digital credentials [38, 58, 63],
(4) as an alternative credential [9, 36, 53, 62],
(5) as "a representation of an accomplishment, interest or affiliation that is visual, available online, and contains metadata including links that help explain the context, meaning, process, and result of an activity" [6],
(6) as a graduation certificate [31],
(7) as "a flexible format to allow educational programs to credential the learning that can sit alongside the curriculum" [41],
(8) as "an online record of achievements, tracking the 'recipient's communities of interaction that issued the badge and the work completed to get it" [62],
(9) as a nano-degree [57], and
(10) as "an online image that tells people about a new skill that 'you've learned" [64].

Micro-Credentials

Micro-credentials have been investigated in research very little so far [7, 8]. All authors synonymize micro-credentials and digital badges. According to [7], "Digital badges or micro-credentials are virtual representations of skill or knowledge, typically a granular one." [8] define micro-credentials and digital badges for being the same as the individual will get a digital badge when fulfilling the micro-credentials requirement. The research focused on possibilities to implement micro-credentials in HEIs via design principles and platform ecosystems [8]. Furthermore, potential benefits and existing vendors have been described and the importance of design choices in that context concerning the convenience and success of implementation and aspects regarding deployment and evaluation of micro-credentials [7].

Alternative Credentials

Alternative credentials are little discussed in research yet [9, 18, 19]. They represent learning outcomes of individuals earned through informal learning that are based on non-degree activities. These competencies refer to timely needs in professional life. [18] [9] refers to badges in the context of alternative credentials and states that they will affect the relationship between higher education and society by representing skills achieved at the workplace instead of study programs. The found literature demonstrates the relevance of alternative credentials by providing a possibility to individuals choosing not to study [18, 19]. [19] points out that a "college diploma is not the only way to the good life, the intellectual life, the cultured life, or the American dream, and it is elitist to push for an educational ecosystem in which college is the only route." Furthermore, several aspects of establishing alternative digital credentials have been discussed, like the design of icons and to represent alternative digital credentials and the represented content, implementation methods, impacts of blockchain technology on alternative digital credentials, and requirements for issuing alternative digital credentials [9].

4.3 Generic Digital Credentials

Term Understanding of Digital Credentials

The conceptualization of the found articles focusing on the category of digital credentials generic in education together with the forward and backward search reveals that the usage of the generic term Digital Credential also has different associations in the found literature:

(1) as academic credentials [24, 25],
(2) as "Credentials are a means by which learners can signal important information about their knowledge, skills, and aptitudes." [32]
(3) as digital badges [38, 58, 63],
(4) as micro-credentials [8], and
(5) as a "digital record of their lifelong learning achievements. Include badges, internships, boot camps, certificates, MicroMasters, and stackable combinations, as well as traditional degrees. They are shareable with employers or other institutions. Institutions can record and manage the achievements of their learners in a way that is easy, safe, and inexpensive, and minimizes the risk of identity fraud" [33].

Technical Aspects of Digital Credentials

Most publications (15) elaborate applications of digital credentials in HEIs using blockchain. News articles have a prevalence of eight, and only one publication analyzes requirements and guidelines for implementing digital credentials.

The authors focusing on blockchain applications for implementing digital credentials in education investigated several aspects:

(1) technical characteristics of the blockchain [12, 15, 24, 77-80],
(2) challenges [23, 77, 78, 81, 82],
(3) benefits [15, 24, 32, 77, 82],

(4) enablers/requirements of using the blockchain [77, 82], as well as
(5) use cases of blockchain-based digital credential implementations [11, 12, 14, 15, 23, 24, 77, 79, 80],

The technical characteristics refer to the aspects such as how to guarantee security within the blockchain, consensus mechanisms in blockchain, different architectures, scalability, and network performance of blockchain technology [78].

The news articles found in the literature give superficial information on digital credentials, referring to the usage of digital credentials in higher education and implementation projects [25-27, 33, 34, 83, 84].

One of the found articles refers to the category requirements and guidelines for implementing digital credentials in HEIs. The publication describes requirements in the context of implementing digital credentials in higher education institutions by proposing a digital credential strategy [32].

5 Discussion

The results of our thematic analysis confirm an increasing interest in digital credentials for HEIs [1]. The number of identified publications per year shows a significant increasing trend in publications from 2015 on.

Further, the topic is of raising interest in the area of HEIs [4] and in the field of Information Systems (IS), which underlies the increasing numbers of publications per year found through the literature search in the context of digital credentials in higher education. The proportion of source categories illustrates that the topic is new in research, as there are only a few book nominations but many conference and journal publications.

Delimitation of Terms

To our surprise, using the terms digital credentials, digital badges, micro-credentials, alternative credentials, and digital academic credentials is not precisely distinct. A more precise specification will follow. Many contributions use digital badges referring to other terms like nano-degrees [57], micro-credentials [8, 22, 36, 47], graduation certificate [31], alternative credentials [36, 53, 62] or digital credentials [38, 58, 63]. Also, there is no unique understanding and usage of the terms '*Digital Credentials*' and '*Digital Badges*' within the research.

The results reveal *digital badges* as a generic term referring to several terms within that context to cover single courses like micro-credentials, alternative credentials, or a credential for a course within a study program. Further, a combination of several courses refers to nano-degrees, graduation certificates, and digital credentials [57]. Table 2 represents the hierarchical conceptualization of digital badges in higher education institutions.

Characte-ristics	Categories						
Degree of Coverage	Single Courses				Combination of Several Courses, Degree		
Content	Digital Creden-tials	Alter-native Creden-tials	Creden-tials for a Course within a Study Progra m	Micro-Creden-tials	Micro Masters / Nano-Degree s / Master Track / etc.	Gradua -tion Certifi-cate	Record of Achie-vement/ Learnin g
Further Specification	Micro-Learning Platform						

Table 2: Conceptualization Digital Badges as Morphologic Box

The term *digital credential* is in the discussion of the literature partially used for the term digital badges [8, 58]. The keywords of the query on the databases were Digital Credentials and Higher Education but resulted in a high number of contributions referring to digital badges (61 contributions). In conclusion, we consider that digital credentials and digital badges belong somehow together. Consequently, precision in the term of digital credentials is necessary. We understand the term digital credential from a verifier perspective regarding higher education as an umbrella term based on all other terms. The IS literature does not specify verifiable credentials in education but is used in the W3C-context [4]. Due to our focus, we do not further discuss this point.

Subsequently, we confirm the findings [33]. The degree of coverage distinguishes between single courses and a combination of achievements. Single courses refer to digital badges or micro-credentials, while the combination of achievements refers to certificates or digital academic credentials as well as MicroMasters. MicroMasters means that a student completes several MOOCs bundled for this purpose at edX for money and then spends 1-2 semesters at a cooperating university for a full Master's degree [85]. Summing up, a digital badge is always a digital credential, while a digital credential must not necessarily be a digital badge. Table 3 represents the hierarchical conceptualization of the terms in the context of digital credentials in higher education.

Characteristics	Categories				
Degree of Coverage	Single Courses			Combination of Lifelong Learning Achievements	
Content	Digital Badges	Micro-Credentials	Certificates	Digital Academic Credentials or Traditional Degrees	MicroMasters / NanoDegrees / MasterTrack / etc.

Table 3: Conceptualization Digital Credentials as Morphologic Box

In conclusion, a digital credential is a general term for digitized versions of a certificate or document representing achieved learning. A digital badge is a sub-term in that context, referring to the reveal of executed learning by specific certificate types like alternative credentials or credentials for a course within a study program. Thus, a digital badge is, in our way, understand as a distinct sign, emblem, token, or mark for a specific learning outcome within the curricula, while a digital credential can be for a whole curriculum such as a Bachelor's degree. Summarizing the study's findings, micro-credentials are mini-certifications within study programs referring to successfully participated courses, while alternative credentials are skill achievements outside the study program. Figure 2 illustrates the delimitation of the relevant terms in the context of HEI study programs.

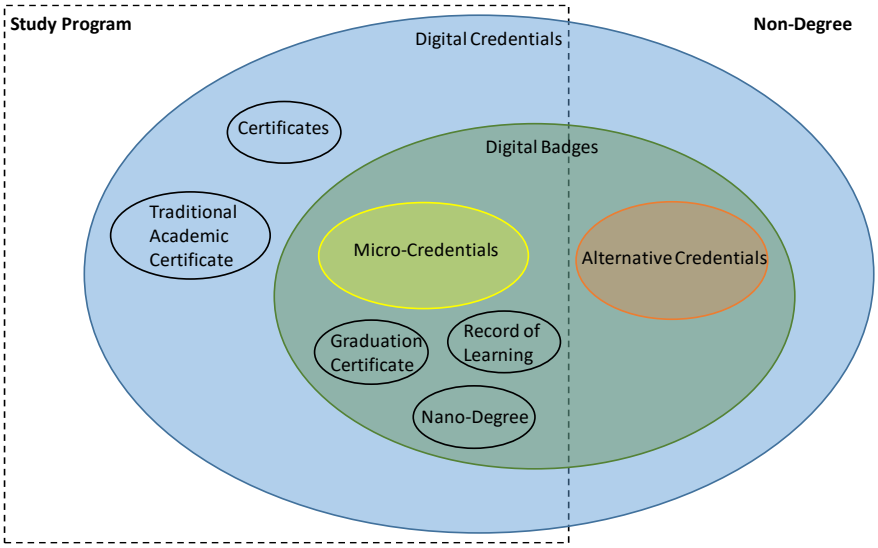

Figure 2: Delimitation of Digital Credentials, Digital Badges, Micro-Credentials, Alternative Credentials

Research Spectrum

Moreover, the research spectrums of the research field of digital credentials in higher education vary between the different areas: research on *digital badges* and *micro-credentials* covers a broad research spectrum, while the spectrum of *alternative digital credentials*, *digital credentials*, and *technical applications* is in comparison to these smaller. The category *technical application* includes studies focusing on the usage of digital credentials and their methodological application. Table 4 demonstrates the research contents of the respective areas.

Cat-egory	Gen	DBa	ACr	MCr	TAp
Con-tents	Strategy /Guide-lines	Implementation (Open Badges)	Rele-vance	Implementation	Blockchain Applications
		Use cases		Benefits	
		Benefits (Open Badges)		Provider Overview	
	Block-chain Appli-cations	Implementation Challenges	Imple-menta-tion	Design Options	Blockchain Applications (Digital Credentials)
	Rele-vance	Influence on Learning Progress		Application & Evaluation	Blockchain Applications (Digital Badges)

Table 4: Investigated Topics, Gen = Generic, DBa = Digital Badges, ACr = Alternative Credentials, MCr = Micro-Credentials, TAp = Technical Application

The conceptualization of literature referring to digital credentials in education yields that many contributions refer to digital credentials applications using blockchain, and only a few references to requirements for implementing digital credentials and common knowledge within that context. As a result, a research gap exists referring to shared knowledge and digital credentials requirements.

6 Conclusion, Limitation, and Future Research

Our literature review shows that higher education institutions' digital credentials play a role in several IS research areas, namely blockchain technology, environmental such as ecosystems and platforms, and e-government. Ideas regarding digital credentials are still in the early stages of research. However, digital credentials in higher

education have been examined in diverse ways, leaving its broader role ambiguous and underutilized in the IS community. We shed light on the claim of different use of names and build a fundament with a more precise definition for the distinction of digital credentials and digital badges in the IS research field.

Our findings underlie limitations such as the applied databases' regulations and, therefore, the capturing only until august 2019. There may be further contributions referring to digital credentials not covered in our literature review approach. However, our focus was the first exploration of the topic, and in the increasing new stage of the topic *digital 'credential,'* we will look for whitepapers to analyze this foundation in more detail. In September 2019, the W3C working group "Verifiable claims" renamed to "Verifiable credentials" [86], so in future research, we will focus on the term verifiable credentials in higher education, too.

This study provides a basis for future research on digital credentials in HEIs, as an overview of the status quo in research is still missing. We hope that this collection of studies will provoke IS researchers and strategic management researchers to step up their collaborative efforts and will provide a fruitful foundation to support the next generation of insights around digital credentials in HEIs. The future of digital credentials in higher education is already possible with today's technology; it has to be applicably discovered.

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