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Digital Credentials in Education – The Situation in Germany and Europe in 2020

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1 Introduction

With each step of our individual educational biography, we collect certificates of achievement. These attest to learning achievements, mostly through proof of exams taken. Currently, as of the end of 2020, such credentials are still being issued almost exclusively on paper. There are, however, good reasons for changing this: Digital Credentials (DC) can be issued, exchanged and verified for authenticity much more efficiently. On the one hand, this results in more efficient processes for learners, education providers and employers (Bertini et al. 2021). On the other hand, DC also open up entirely new possibilities, for example when they include machine-readable information on the respective learning outcomes. If, in the future, not only learning opportunities and the associated DC are described in this way but also job advertisements contain information on the competencies sought in standardized form, this will enable automatic matching. Algorithms can then answer questions such as "Which person is the best fit for a job?" or "Which targeted training will bring me closer to my desired profession?" (Rentzsch and Staneva 2021). These potentials of DC form the framework for a range of projects initiated in recent years – both "top-down", i.e. primarily policy-driven, and "bottom-up", initiated by individual stakeholders or alliances from the education sector itself. This review summarizes these efforts, focusing on developments in Europe. However, many similar projects exist worldwide (see e.g. Kato et al. 2020; Chakroun and Keevy 2018).

Following a description of the major education policy projects currently targeting DC in chapter 2 – at the level of the European Union (EU), in Germany and in other European countries –, a survey of focused bottom-up projects is provided in chapter 3. This mainly concerns projects initiated by educational institutions and networks of such, as well as private-sector developments. Due to the close interconnection of the political level and the initiatives of individual stakeholders, for example via public R&D funding programs, it is inherently difficult to separate the discussed projects according to the "top-down vs. bottom-up" system. At the same time, an overarching distinction based on technical aspects would be even less suitable, given that the majority of projects touch on a range of such aspects, for example different DC data standards. Accordingly, the hybrid structure of the two chapters represents a compromise, aiming to facilitate readability and quick reference. The chapter introductions provide further comments on this. The outlook in chapter 4 summarizes the most important factors for the DC idea to become generally accepted and successful, which also requires a further sharpening of the corresponding terminology.

2 Overarching political projects

As explained above, clearly separating the DC projects under consideration according to (and as suggested by) the titles of this and the following chapter is hardly possible. EMREX provides an example of this right at the beginning: It is neither a genuinely "political" project nor does it currently still receive public funds. Nevertheless, the great influence it had and has on many other projects that do fit these criteria suggests an initial treatment.

2.1 European level

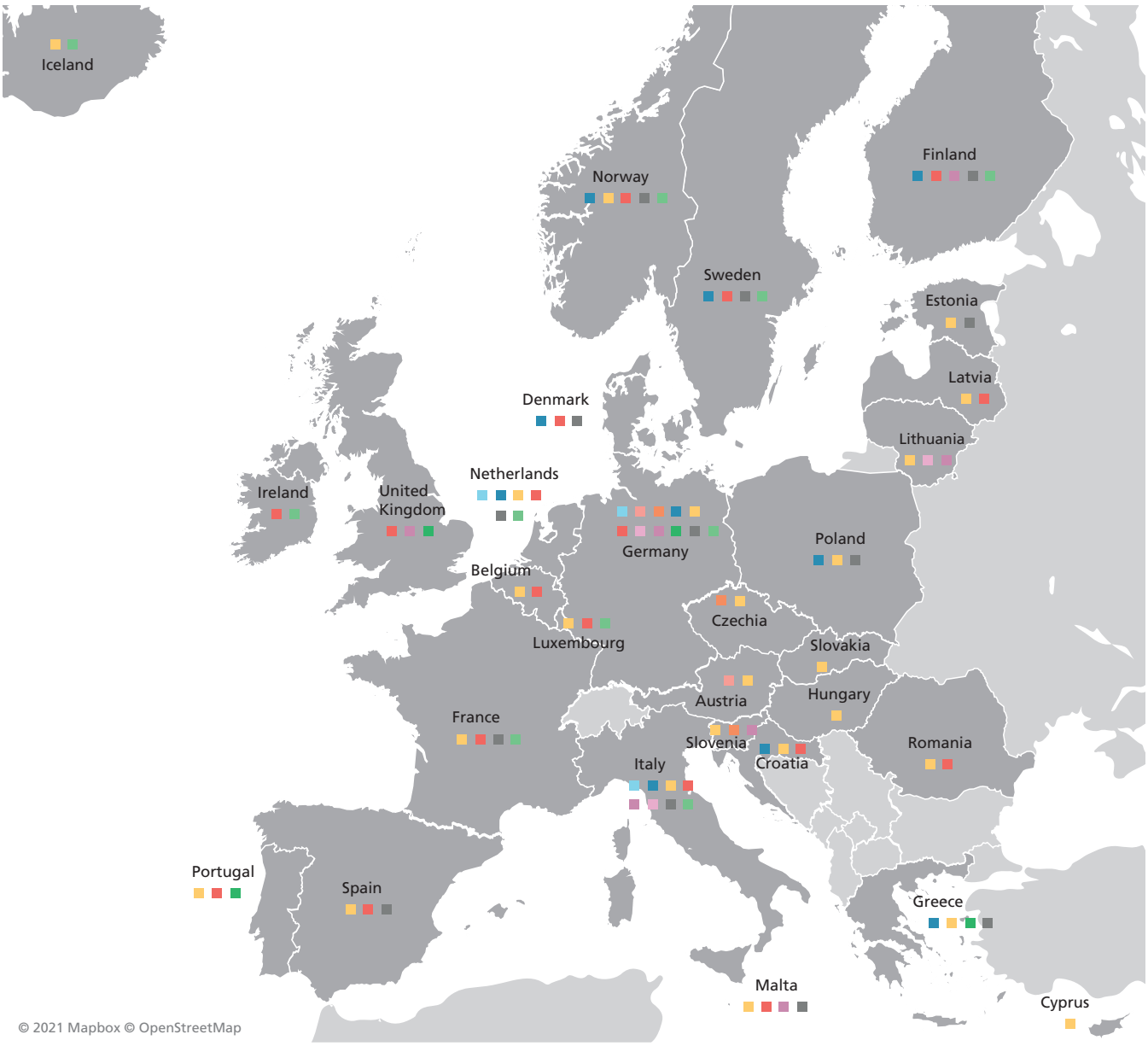
Figure 1 illustrates the extent to which European countries are cooperating on the topic of DC as of the end of 2020, including global networking activities. This survey is based on the membership of individual or multiple national stakeholders, respectively, in international R&D projects on the one hand and in networks for topic-specific exchange on the other. An entry indicates that at least one partner is located in the respective state. Further, while the two exchange networks IMS Global Learning Consortium and Groningen Declaration Network are outside the focus of this publication, they are important especially for the long-term global alignment of DC efforts. For this purpose, states with at least one network member are marked; these are rarely government stakeholders, more often educational institutions, companies and foundations. Overall, the figure underscores the already considerable degree of networking on the topic. Adding to this, despite extensive research and inquiries, no claim can be made to completeness. This also applies to the additional highlighting of countries in which, based on this research, there currently exist noteworthy national and (more or less directly) politically controlled DC projects or working systems, e.g. for DC data management and exchange. The majority of these projects, too, will be addressed in the remainder of the text.

EMREX and **Erasmus Without Paper** (EWP) are two influential projects that have been dedicated to the cross-border exchange of student data for several years. Both projects originated from the efforts of the Rome Student Systems and Standards Group (RS3G), which started its work on data exchange issues already in 2007. Further, both were supported financially by the EU through its Erasmus+ Program, until 2017 and 2019, respectively, and have since been partially continued on the initiative of the participants. The two projects overlap in terms of both members and goals, yet there are clear differences in implementation and focus (see e.g. Christmann-Budian et al. 2018; Mincer-Daszkiewicz 2017). To date, ten EU countries with more than 1,600 educational institutions are participating in the EMREX network. In 2019, more than 30,000 data transfers took place between so-called EMREX National Contact Points (NCP) and EMREX Clients, the two core building blocks of the EMREX architecture[1]. In Germany, the University of Göttingen has been a full EMREX member and the FU Berlin an associate member since June 2020. In addition, the Harz University of Applied Sciences (UAS) also operates an EMREX NCP. Other members are the German Academic Exchange Service (Deutscher Akademischer Austauschdienst; DAAD) and the Foundation for Admission to Higher Education (Stiftung für Hochschulzulassung). A central EMREX output that was also adopted by EWP is the ELMO data standard[2]. This is used to exchange module data in both projects and has influenced many of the other efforts below. ELMO is an XML format with machine-readable data that further allows PDF attachments. The components developed in EMREX, EWP and other EU-funded projects are part of the Erasmus+ digitization agenda; they will therefore gradually become mandatory for all institutions participating in the Erasmus program in the coming years[3]. The deadline for the Transcript of Records (ToR), as a DC for completed modules, is 2023. Further, according to plan, the vision of a "European Education Area" – as first outlined by the European Commission (EC) in 2017 – is to be realized by 2025 and Erasmus to be fully digitized (EU-COM 2020).

When EWP's funding expired at the end of 2019, more than 300 universities from eight EU countries participated in the network, according to project communications[4]. Despite this, the numbers of actual data transfers performed were still low. It should be kept in mind, however, that the exchange of a wide variety of Erasmus-relevant data in EWP, in conjunction with an online dashboard solution for universities without existing mobility management systems, defines a very broad and complex range of tasks. EMREX, on the other hand, focuses entirely on the standardized exchange of module data and, since the official end of the project in 2017, no longer puts its main effort into further technical development. Rather, it aims to expand the existing network within Europe and beyond. While EWP may therefore have a more direct influence on the further digitization of the Erasmus program, EMREX – with ELMO as a standard that can be used and extended in a wide variety of contexts – has had, and continues to have, the greater influence on the projects presented below.

1 https://emrex.eu/technical [02/15/2021]
2 https://github.com/emrex-eu [02/15/2021]
3 https://ec.europa.eu/education/education-in-the-eu/european-student-card-initiative_en [02/15/2021]
4 https://www.erasmuswithoutpaper.eu/news/end-erasmus-without-paper-project [02/15/2021]

Figure 1
International cooperation and networking of European countries on the topic of digital credentials in education



The mapped projects and exchange networks are discussed or mentioned throughout the text. This also applies to a selection of national projects, as indicated, which are not referenced individually here.

July 1, 2020 saw the launch of the new **Europass portal**[5], which was developed under the auspices of the EC's Directorate-General for Employment, Social Affairs and Inclusion (DG EMPL) and, among other things, directly addresses DC. Europass as a concept and resource has been advanced since 2004 by the EC and the European Centre for the Development of Vocational Training (Cedefop) in cooperation with the member states[6]. Each participating country runs a Europass contact point. In Germany, this is the National Agency (NA) "Education for Europe" at the Federal Institute for Vocational Education and Training (Bundesinstitut für Berufsbildung; BIBB). For many years, the Europass platform served users primarily as a multilingual editor for CVs in a standardized EU format. It also provided the templates and specifications for the EU mobility and transparency documents Diploma Supplement, Certificate Supplement and Mobility Certificate for universities, companies and schools. Based on the so-called Europass Decision (EU 2018a), a completely new portal with significantly enhanced functionality for both users and member states has been developed since 2018. This is available in 29 languages, including Arabic, and intended to accompany EU citizens as a supporting tool throughout their entire educational and professional career. After setting up a user account, a profile can be created and a "library" is available for storing all kinds of educational documents. Further, the functionality of the editor for resumes and application letters has been significantly expanded. An account is not required to search for learning opportunities and qualifications throughout Europe.

An important novel component of the Europass project is the **Europass Digital Credentials Infrastructure**[7] (EDCI), through which DC can be issued in the EDC format developed for this purpose, stored and verified by third parties. The EDC format is an extension of the international standard for "Verifiable Credentials" (W3C VC[8]) published by the World Wide Web Consortium (W3C) in 2019. With the latter it is fundamentally compatible, but includes several additional fields specific to DC in education. These are Learning Activities (e.g. courses and modules), Achievements (the most common type of which are Qualifications, which in turn are linked to certain types of exams), Entitlements (e.g. the right to study at a university) and Accreditations (e.g. the validity of a Polish degree in France). These extensions are largely based on the preliminary work of the EU-funded MicroHE[9] project, which was managed by Baden-Württemberg Cooperative State University (Duale Hochschule Baden-Württemberg). They make it possible to capture and certify both institutionalized and informal learning of all kinds. Furthermore, as a special requirement of the EDC format, only qualified electronic seals as defined by the EU eIDAS[10] Regulation (EU 2014) may be used for the signature of the issuing institution. Only then is the issued EDC legally valid and equivalent to a handwritten document throughout the EU. The integrity of the seal and thus the DC is checked during its validation in one of six defined steps[7]. In the medium term, there are also plans to make EDC and the recipient information they contain blockchain-verifiable (see section 3.1). This was already demonstrated in a prototype[11] in collaboration with the European Blockchain Services Infrastructure (EBSI) project.

The issuing of EDC for educational institutions[12] is possible both interactively in the Europass portal, by uploading an Excel template or a ready-formatted EDC file, and via an API[13]. To this end, a pilot phase took place in 2019/20 with educational institutions in 18 EU member states, including three universities, three Chambers of Industry and Commerce[14] as well as two schools in Germany. Verification can also be performed inter-actively, via the API or via specifically implemented software (that adheres to the EDCI verification specifications). EDC can be stored in the Europass document library as well as in corresponding "wallets"[15] implemented by member states or private sector stakeholders; in addition, individuals can store their EDC files themselves. Wallets offer the advantage that they can directly integrate the selective and secure sharing of DC with third parties, e.g. employers. The possibility to automatically convert existing DC issued in the Open Badges (see section 3.2) and ELMO formats into the EDC format is currently being investigated. Further, the EDC format and EDCI concepts will most likely influence the current work of the W3C task force "Verifiable Credentials for Education". In the medium term, EDC may be issued for those learning opportunities and qualifications in Europe that have previously been entered into the Qualifications Dataset Register (QDR) by the respective

5 https://europa.eu/europass [02/15/2021]
6 https://ec.europa.eu/futurium/en/europass/history-europass [02/15/2021]
7 https://europa.eu/europass/en/europass-digital-credentials-interoperability [02/15/2021]; https://ec.europa.eu/futurium/en/system/files/ged/edci_presentation.pdf [02/15/2021]
8 https://www.w3.org/TR/vc-data-model [02/15/2021]
9 https://microcredentials.eu [02/15/2021]
10 https://www.cryptomathic.com/news-events/blog/understanding-eidas [02/15/2021]
11 https://ec.europa.eu/cefdigital/wiki/display/CEFDIGITALEBSI/Diplomas [02/15/2021]
12 https://europa.eu/europass/digital-credentials/issuer/#/home [02/15/2021]
13 "Application Programming Interface". Existing student information systems can be extended for directly issuing EDC via calls to this API.
14 In Germany, the Chambers of Industry and Commerce and the Chambers of Crafts represent the business interests of enterprises in different geographic regions. Their roles are defined by law.
15 Note: The frequent use of the term "wallet" in the general DC context, in the sense of DC "collection and management folders" for users, is unrelated to its very specific meaning in the blockchain context.

member states, a database established specifically for this purpose. Independently of DC, this is necessary so that these offerings can be found by Europass users and, optionally, automatically suggested to them (see below). The corresponding QDR data formats, Qualifications Metadata Schema (QMS) and Learning Opportunities Metadata Schema (LOMS), have been developed in conjunction with the EDC format, under the umbrella term "Europass Learning Model". Information on, for example, a degree that is already available in the QMS format – such as title, modules and type of examination – therefore only needs to be supplemented by a few additional points in the EDC that certifies the degree, such as recipient or date. Describing the degree is thus "worthwhile" in light of the DC issued later.

From the outset, Europass was also intended as a tool for information exchange between the formal sub-sectors of education on the one hand and between the education system as a whole and the labor market on the other hand. It is no coincidence that the new Europass portal was launched in parallel with the presentation of a new version of the EU Competence Agenda[16], as one of the twelve actions listed therein.Conceptually, this is achieved by focusing on the skills, competencies and expertise that individuals either already have or can acquire. To this end, Europass uses the **European Classification of Skills, Competences, Occupations and Qualification**s[17] (ESCO), which was also developed by the EC's DG EMPL in cooperation with a large number of experts from business and education. At its core, ESCO comprises two hierarchical classifications, often referred to as taxonomies: one for skills, competency and knowledge concepts – the "skills pillar" – and one for occupations. The original third pillar, a non-hierarchical database of qualifications in Europe, is now formally part of the Europass/QDR infrastructure. Importantly, the pillars are cross-referenced: Connections denote, on the one hand, which skills are required in certain occupations and, on the other hand, via which qualifications learners can obtain them. When Europass users fill in their personal profile or create a CV, the system suggests suitable ESCO concepts for relevant fields. At the same time, institutions can use ESCO concepts to describe the intended learning outcomes of their offerings using the QDR formats; this information is then also included in any later-issued EDC, as described above. Furthermore, the job advertisements in the EU job portal EURES are to be annotated with ESCO concepts in the future, including the skills sought in each case. Based on these three core types of ESCO-annotated documents – CV with acquired DC, descriptions of learning opportunities and job descriptions – different recommender and matching systems may be implemented. Currently, Europass users are already suggested learning opportunities from the QDR based on the ESCO concepts in their profiles.

2.2 Germany

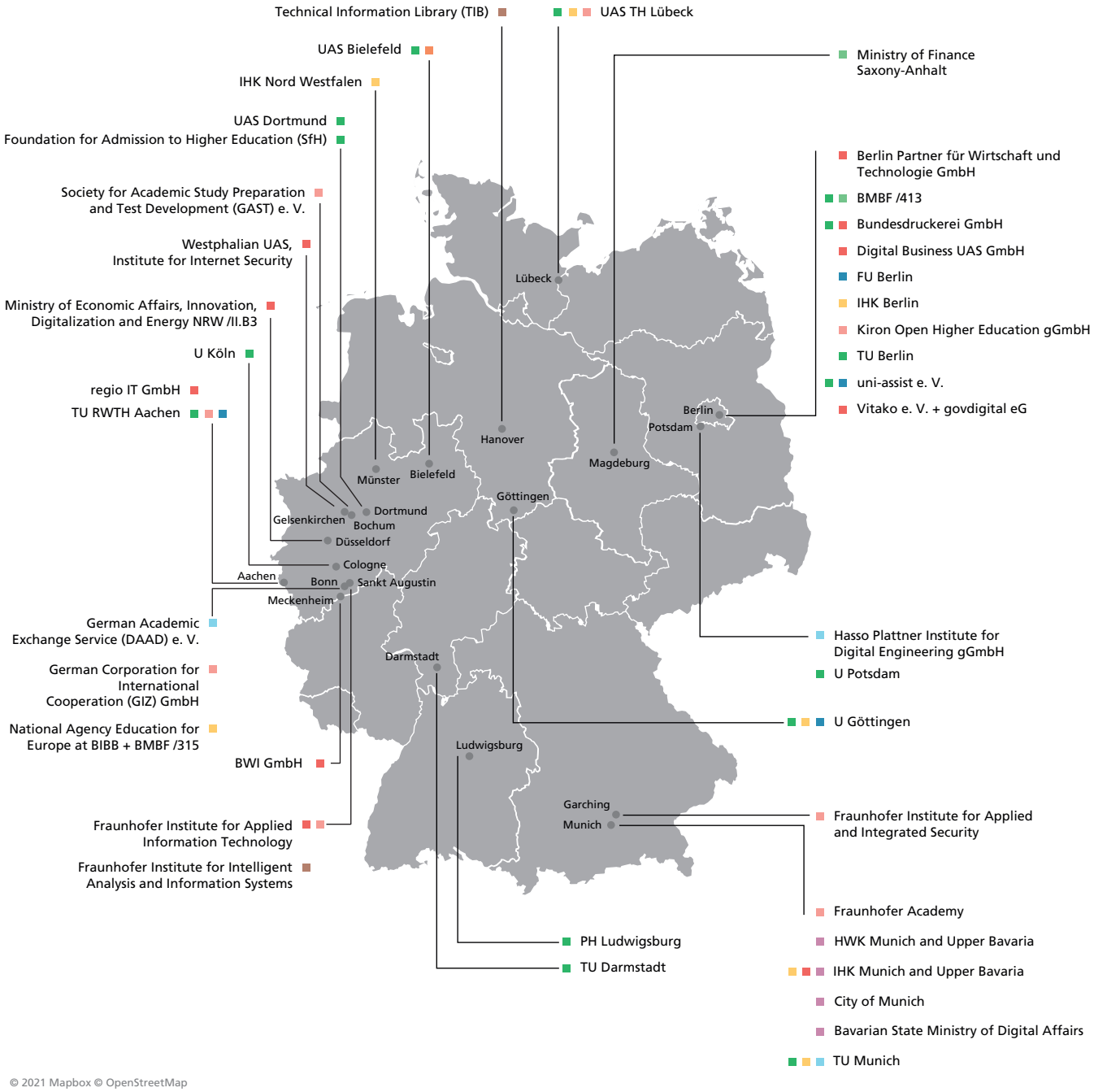
In Germany, three major DC projects with direct government involvement at the federal and national levels are currently underway. These are, on the one hand, the projects "Platform for International Student Mobility" and XHochschule, which are closely intertwined in terms of both contents and personnel, and, on the other hand, the "Netzwerk Digitale Nachweise", with a preliminary focus on school certificates. Figure 2 shows the stakeholders involved in these and further, international projects.

The **Platform for International Student Mobility** (Plattform für Internationale Studierendenmobilität; PIM) project was launched in 2019 under the auspices of the German Federal Ministry of Education and Research (BMBF) and comprises a network of eleven universities to date. At its core, PIM is concerned with the comprehensive digitization of the exchange of module data to improve the processes for crediting study activities, including future virtual ones, of German students abroad and foreign students in Germany. The platform was initially designed to serve as a bridge between the various student information systems (SIS) of German universities and EU-wide projects in this area, particularly EMREX. For this purpose, an extension of the ELMO format was developed, which allows to store module information that goes beyond the standardized ToR with respect to contents. The development of interfaces for exporting to and importing from this format is currently underway, with tests being run by several PIM partner universities using different SIS. The extended module information plays a role especially in the context of the second core component of PIM, the development of a central module database. In this database, the participating universities store information on the contents of study modules they provide and denote which modules from other universities, especially foreign ones, have already been recognized for which of their own degree programs. This aims at making individual recognition workflows and decisions faster, more transparent and more consistent. It became clear early on in the project that a close collaboration of PIM and the overarching XHochschule project (see below) would result in significant synergy effects, with the former effectively acting as a "prototype laboratory" for the standardization work done in the latter. This point will be taken up again below.

XHochschule (or XHigherEducationInstitutionExchange; XHEIE) is a standardization project that was also launched in 2019.

16 https://ec.europa.eu/social/main.jsp?catId=1223&langId=en [02/15/2021]
17 https://ec.europa.eu/esco/portal/home [02/15/2021]

Figure 2
Networking of German stakeholders on the topic of digital credentials in education



BIBB: Federal Institute for Vocational Education and Training; BMBF: Federal Ministry of Education and Research; eG: Registered Cooperative Society; e. V.: Registered Association; GmbH: Limited Liability Company (LLC); gGmbH: Non-profit LLC; HWK: Chamber of Crafts; IHK: Chamber of Industry and Commerce; PH: University of Education; TU: Technical University; U: University; UAS: University of Applied Sciences. For ministries, the responsible unit is also indicated, respectively.

Notes: DAAD membership in the Digital Credentials Consortium, as indicated here, is currently being sought; a close exchange already exists. For the PIM project, associated partners are shown in addition to the member universities, to illustrate the high degree of networking.

Under the leadership of the federal state of Saxony-Anhalt and the BMBF, more than 60 experts are working across disciplines to create a data exchange specification for study-related data. The foundation for the XHochschule project is the German Online Access Act[18] (OZG), therein specifically the services defined for the "Lebenslage" (life situation[19]) academic studies. Based on this act and the corresponding e-government laws of the federal states, universities are urged[20] to offer their administrative services digitally to citizens – in this case, prospective students, students and alumni – by the end of 2022. As already envisaged in PIM, this requires uniform communication between different SIS and between SIS and central databases, for example a possible national "citizen's account". XHochschule is developing both a data standard and an API for data exchange (Paul et al. 2020). The project is oriented toward concrete use cases, initially the issuing of certificates and students changing universities during their studies. At a later point, enrollment certificates and ToR will also be considered. In December 2020, the project published the specifications of the XHochschule and XBildung standards in version 0.1 (BMBF and Land Sachsen-Anhalt 2020). The latter forms the framework for the specialized OZG implementation modules – alongside XHochschule e.g. XSchule and XAusbildung for school and vocational training periods – and thus specifically addresses the exchange of data between the various subsectors of education. Importantly, these developments consider the W3C VC standard and its Europass offshoot EDC (see section 2.1), and further take into account the extended ELMO standard from PIM. The XHochschule format is itself designed as a derivative of the EDC format, with specific additions resulting from the canonical OZG development, in particular from the overarching public administration standard XÖV. The existing university network behind the PIM project is used to iteratively test these developments. For this purpose, then current plan is to successively convert the PIM building blocks, such as the export and import interfaces, to use XHochschule instead of ELMO as the basic exchange format; in the medium term, a wrapper solution integrating the ELMO format is most likely. In the long term, at least "soft compatibility", via conversion tools, with both the EDC and ELMO standards is the goal. Likewise, the project members are in the process of adapting the data flow originally envisaged in PIM, which was largely based on the EMREX NCP concept (in this case including a module database) with regard to an OZG citizen's account.

The now de facto existing cooperation project **PIM-XHochschule** further aims to implement a national DC wallet, similar to the EU-wide Europass library and to developments in other European countries (see sections 2.1 and 2.3). Mutual efforts toward compatibility (see above) should ensure that future students will be able, for example, to use their digital certificates issued in Germany throughout the EU. In this case, an export in EDC or ELMO format could take place from the national wallet, after which the student initiates an import into his or her own Europass wallet. The conceptual and technical integration of such a national DC wallet into the overarching OZG developments described above remains the subject of ongoing work. For uniform identity and role management and the desired "Single Sign-on" (SSO) principle, the PIM-XHochschule team also draws on preliminary work from the DAAD's project Digital Campus, which is concerned with facilitating information and application processes for international students interested in studying in Germany. Further, there is ongoing exchange with the "European Digital Student Service Infrastructure" (EDSSI) project, which started in October 2020 and focuses, among other things, on the further development of EWP and its synergies with EMREX.

Obvious links, both political and with regard to contents, exist between the implementation of the OZG and the European Single Digital Gateway Regulation (SDGR; see EU 2018b). The former regulates the digitalization of administration in Germany, while the latter requires all EU member states to ensure that, where such digital services are made available to citizens, corresponding access must also be created for EU-foreigners[21]. For this reason, contact has also been established between the XHochschule project and the relevant EU stakeholders, mediated by the Federal Ministry of the Interior, Building and Community (BMI), which coordinates the SDG efforts in Germany. In this context, it is yet unclear how the concrete development of a "Common Data Model on Educational Evidences" within the framework of the ISA² program[22] of the EC (led by the Directorate-General for Informatics, DG DIGIT; until 2020) will be aligned with the Europass developments on the EDC format on the one hand and national efforts such as XHochschule on the other hand. The same applies to corresponding work in the "Digital Europe For All"[23] (DE4A) project, launched in 2020. The concrete background of the DC developments in the context of the SDG is Article 44 of the SDGR, which describes, among other things, a system for the "cross-border automated exchange of evidence".

18 https://www.gesetze-im-internet.de/ozg/index.html [02/15/2021];
https://www.onlinezugangsgesetz.de/Webs/OZG/EN/home/home-node.html [02/15/2021]
19 The implementation of the OZG is structured by topics and citizens' life situations or life events. The topic education includes, for example, academic studies, vocational training and continuing education.
20 Degree and mode of obligation for universities to implement the requirements vary widely among the federal states (see Ruschmeier et al. 2020).
21 EU-foreigners are citizens of other EU member states, respectively. These may be interested, for example, in studying in Germany.
22 https://ec.europa.eu/isa2/home_en [02/15/2021]
23 https://www.de4a.eu [02/15/2021]

Like XHochschule, the **Netzwerk Digitale Nachweise** ("Digital Evidences Network"; NDN), founded in 2020, is also directly linked to the OZG. Originally, it goes back to the Coordination Project Blockchain of the German IT Planning Council[24], which considers DC as a possible use case. In the context of implementing the OZG topic Education, a network was then founded based on this preliminary work with currently 17 partners from different educational subsectors as well as from business and research, led by the Ministry of Economic Affairs, Innovation, Digitalization and Energy of the federal state of North Rhine-Westphalia. Since the publication of a joint white paper on the topic (Netzwerk Digitale Nachweise 2020), the NDN has focused on the use case of blockchain-verifiable school certificates (see section 3.1). In this context, the network is also looking to connect to EMREX in terms of infrastructure. In a first prototype presented by the Bundesdruckerei[25], as an NDN member, at the EMREX annual meeting in June 2020, a PDF with integrated ELMO-XML was used as the data format (EMREX itself follows the reverse principle). This involved the transfer of certificate data from the EMREX NCP of the University of Göttingen and the Harz UAS at the request of a Swedish EMREX node. Independently of blockchain usage, the OZG implementation project School Certificate for the life situation School also deals with certificate digitization. In 2019 already, experts from ministries, school authorities and schools (including students) from five federal states worked together to develop solutions within the framework of an OZG Digitalization Lab (Carstens 2021). According to the vision formulated there, citizens should be able to manage their certificates in a standardized wallet from 2022 onwards. Obviously, the data exchange and wallet developments for school certificates largely coincide with those in the higher education area (see above). The NDN and PIM-XHochschule projects therefore have to coordinate their efforts.

2.3 Other European countries

Large-scale national DC projects with direct or indirect government involvement exist in various EU countries, and some of them have established working systems. Particularly in Scandinavia and the Netherlands, digital, automatically verifiable education certificates have been the norm for several years, mostly in the form of digitally signed PDF files. This is driven by central databases and corresponding networks of educational institutions created early on. On top of this, two trends have become apparent recently. First, new or previously lesser-known projects are emerging, in more countries and with an increased focus on novel DC design and verification concepts such as badging and blockchain solutions (see sections 3.1 and 3.2). Second, international data exchange is becoming increasingly important, i.e., the networking of national systems with each other. This may require adaptation and further development of these systems and, at the least, involves the creation of import and export interfaces for internationally shared data formats. Corresponding projects from France, Italy, the Netherlands, Poland and the Scandinavian countries are presented below.

In **France**, the diplome.gouv.fr[26] portal, jointly developed by the Ministry of National Education, Youth and Sport and the Ministry of Higher Education, Research and Innovation, was launched at the end of 2019. Similar to the Dutch system, which has existed for some time (see below), citizens can obtain digital versions of their previously acquired paper certificates in PDF format. These can also be verified by third parties, such as employers, for which a key code is generated in each case. This code, along with the name of the person presenting the certificate, is used for verification on the website. In principle, it is therefore sufficient to mention the certificate and the key in a resume; the PDF file itself does not have to be shared. In addition, a basal wallet solution is offered: The DC can be transferred free of charge to the "digital vault" Digiposte of the French postal company La Poste, for long-term storage. After an initial focus on school and vocational training certificates, the portal is currently being expanded to include university diplomas. For authentication, either a custom user account or the national SSO solution FranceConnect is used. With the latter, users can choose from a number of accounts they may already own, e.g. at La Poste.

In **Italy**, the non-profit consortium CINECA, which includes 92 public institutions – among those all state universities, various research institutions and the Ministry of Education – has been operating the DC platform Bestr[27] since 2015. CINECA, in addition to coordinating distributed high-performance computing in Italy, also centrally develops software for science and administration. The integration of the Bestr issuing system with ESSE3 (Bertazzo et al. 2016), the SIS used by more than 80% of Italian universities, allows the latter to issue DC according to the Open Badges standard (see section 3.2) and, as an option since 2019, to make these DC blockchain-verifiable using the Blockcerts standard (see section 3.1). Currently, more than 100 institutions and projects already offer Bestr badges, including over 30 universities and the official Italian MOOC platform EduOpen. In addition, companies also participate in the Bestr network; for example, they can tag

24 The German "IT-Planungsrat" is a central steering committee responsible for national IT cooperation in the public sector, specifically coordinating the national and federal state levels; https://www.it-planungsrat.de/EN/it-planing-council/IT-Planning-Council_node.html [02/15/2021]
25 The Bundesdruckerei ("Federal Printer") is a government-owned company producing e.g. the German identity card, passport and driver's licence.
26 https://diplome.gouv.fr [02/15/2021]
27 https://bestr.it [02/15/2021]

certain badges as valuable and sought-after. The focus of the portal has so far been on so-called "microcredentials" (see also chapter 4) for specific skills and competencies acquired in short-format courses. However, the University of Padua, for example, following a one-year test phase with the issuance of Bestr badges for extracurricular activities and language courses, started to also issue such badges together with its (also digital) diplomas and diploma supplements already in late 2018. These include details of the skills and knowledge gained and proven in exams, as well as the final grade and thesis title. In total, the university currently offers more than 200 badges on Bestr. A second example is the University of Turin, which has been offering badges for one- to two-year postgraduate Master's degrees in specific areas of medicine since 2020. The issuance of Blockcerts badges, so far offered by the universities of Milan and Padua, follows the Blockcerts standard protocol[28]; students can therefore use the Blockcerts app for DC management.

A second blockchain-based service, DiploMe, has been running in Italy since 2019. It was developed by CIMEA, the Information Center on Academic Mobility and Equivalence. CIMEA promotes academic mobility and provides information and advice to individuals and institutions on the recognition of Italian qualifications abroad and vice versa. DiploMe is, at its core, a wallet, into which institutions can issue DC to citizens. This concerns certificates of all kinds, e.g. the certificates of equivalence issued by CIMEA. The technical background was described in a white paper (Lantero and Marchionni 2019). According to this, DiploMe uses the W3C-VC standard (see section 2.1), making the issued DC Europass-EDC-compatible.

In the **Netherlands**, the SURF technology cooperation network of Dutch universities and research institutions has been working on a badging system since 2016. As in Italy, the goal is to improve the visibility of individual competencies in education and work. After a proof-of-concept phase of the EduBadges project with eleven educational institutions starting in 2017, a pilot study followed with 17 institutions and involving the Ministry of Education; detailed reports exist on both phases (SURF 2019; SURF 2020). Based on this, the decision was made in 2019 to establish EduBadges as a central platform[29] and infrastructure for awarding badge-DC by Dutch educational institutions. Tilburg University then awarded the first EduBadge-DC in 2020[30]. While the system, derived from the Badgr open-source implementation for issuing and verifying Open Badges, is thus running in production mode, it is still unclear whether common use cases and specifications will be agreed upon among the institutions in the medium term. In contrast to Bestr in Italy, none of the participating institutions awards badges for genuine academic achievements or degrees so far; their application is limited to extracurricular learning activities. Nevertheless, various extensions[31] to the Open Badges standard have been developed in the project, for example for storing learning outcome descriptions and ECTS[32] points earned. Furthermore, an "eduID" was created especially for the project, as a cross-institutional identifier for learners. This is to be replaced by the use of the Dutch DigiD in the future, based on corresponding legislation. The national storage of badge data is also being explored, through the Dienst Uitvoering Onderwijs ("Education Executive Agency"; DUO). This agency reports to the Dutch Ministry of Education and has been operating the national degree database Diplomaregister since 2012[33]. Dutch educational institutions, particularly schools and universities, are required to submit all degrees earned by citizens to this register. They can be downloaded there for life in the form of digitally signed PDF files that have the same legal status as the respective original certificates. DUO also operates the Dutch EMREX NCP and Client based on the Diplomaregister.

In **Poland**, where the University of Warsaw joined the EMREX network in 2017, it was decided early on to use the EMREX building blocks for receiving and sending student data on the national level, too. This is not the case in any other country to date and happens within the framework of the MOST mobility program, in which more than 25 Polish universities participate. Given that Poland had not implemented a national register of student records at the time (this is, as in Germany, still the case in 2020), a "peer-to-peer" approach was taken: Since all institutions participating in MOST use the same SIS "USOS", both the EMREX-Client and the NCP were integrated into the associated web app USOSweb. Thus, each institution can function as both client and server, allowing bidirectional data exchange with every other institution (and, further, allowing each to connect to the international EMREX network in either role). This solution was implemented quickly[34] and has been in active use since 2017.

Scandinavia as a whole, like the Netherlands, is considered a DC pioneer. Digital degree registers, for example, also exist in Finland, Norway and Sweden. The respective user portals are

28 https://blog.bestr.it/en/2019/06/13/how-get-your-blockcerts [02/15/2021];
https://blog.bestr.it/en/2019/06/13/reading-verifying-and-sharing-blockcerts-bestr [02/15/2021]
29 https://edubadges.nl [02/15/2021]
30 https://www.tilburguniversity.edu/students/tilburg-university-presents-first-edubadges-students [02/15/2021]
31 https://wiki.surfnet.nl/display/Edubadges/Metadata+extensions [02/15/2021]
32 The European Credit Transfer System (ECTS) describes a credit point system for measuring and comparing study activities within the EU.
33 https://www.duo.nl/diplomaregister/diplomaregister.jsp [02/15/2021]
34 https://emrex.eu/case-poland [02/15/2021]

Koski[35] with the VIRTA database[36] in Finland (since 2018), Vitnemålsportalen[37] in Norway (since 2017) and Ladok[38] with the LadokPing network for data exchange, operated "bottom-up" by a university consortium, in Sweden (since 2016); in addition, Sweden also operates a central database for school certificates, BEDA[39]. Both certificates and ToR can be downloaded by users of these portals as signed and online-verifiable PDF-DC, via a link and key code, as described above for the French system. In Norway, a dashboard solution exists for sharing the DC with third parties. The EMREX NCP of the three countries are fed from the systems mentioned above, too. Furthermore, a number of HR systems in Norway can already directly import data from the diploma portal via an API, at the request of applicants. In Finland and Norway, users log into the systems using a selection of national eID types, again similar to the French system. In Norway, it is also possible to use an EU eIDAS-ID. In Sweden, the respective university logins are used for Ladok.

Linné University was the first in Sweden to issue digital certificates at the end of 2017, and another eleven have since followed. These institutions no longer issue paper certificates. In neighboring Denmark, too, a large number of universities are now issuing degree certificates only digitally, starting with the University of Odense in 2018. These DC are issued directly to the state's e-Boks citizen mailbox, which users log into with their national "NemID". In Finland and Norway, in addition to the systems described above, most universities currently still also issue paper certificates. All of the Scandinavian DC systems described above are under active further development. In Sweden, based on preliminary work by Linné University, a national study is underway with the goal of introducing a uniform system for all universities, including a wallet solution. Similarly, Norway is currently extending its diploma portal to school and vocational education. In Finland, information on students' stays abroad, for example from EMREX, will be collected in VIRTA in the future, partly for statistical purposes[40]. In Norway, EMREX is also becoming increasingly important and is now used there for the recognition of foreign degrees as part of the NOKUT portal, which already accepts documents from eight countries[41].

35 https://koski.opintopolku.fi/koski [02/15/2021]
36 https://wiki.eduuni.fi/display/CSCOPTIETOR/VIRTA+in+English [02/15/2021]
37 https://www.vitnemalsportalen.no/english [02/15/2021]
38 https://www.student.ladok.se/student/loggain [02/15/2021]
39 https://www.uhr.se/en/start/system-support-services/system-support-services-for-higher-education-institutions/the-grades-database-beda [02/15/2021]
40 https://www.csc.fi/-/korkeakoulujen-opiskelijoiden-kansainvalinen-liikkuvuus-ja-tiedonkeruu-sujuvoituvat [02/15/2021]
41 https://norric.org/nordic-report-looks-into-digitalisation-in-recognition [02/15/2021]

3 Focused bottom-up projects

Transversal, in a sense, to the large-scale projects described above, whose focus is primarily on networking and standardization and which have a strong "top-down" component in organizational terms, there exist a large number of projects that focus on specific DC technologies and concepts and that are (most commonly) driven by research networks and individual stakeholders. These mainly fall into the categories of blockchain-verifiable DC and badge-DC. Direct interfaces between educational institutions and the private sector are found in those areas, too: The purchase of corresponding ready-made DC solutions is already common in the United States, for example, and is also becoming more frequent in Europe. In addition, two projects with a pioneering status in their respective areas are summarized at the end of this chapter.

3.1 Technical focus Blockchain

A large number of research and pilot projects, and increasingly also private-sector providers, develop software and infrastructure for issuing and verifying blockchain-anchored DC (see e.g. Fedorova and Skobleva 2020; Camilleri et al. 2019; Kamišalić et al. 2019; Grech and Camilleri 2017). In this process, a fingerprint in the form of a so-called hash value is generated from the DC's machine-readable data upon issuance. This is written to a blockchain data structure, which at its core corresponds to a growing database[42] that is continuously mirrored on many geographically distributed servers. The manner in which the individual data blocks within the chain are interlinked makes the subsequent manipulation of individual entries impossible. For subsequent verification of the integrity of the DC's data, i.e., its consistency with the original state when issued, the hash value is recalculated and compared with the relevant entry in the blockchain. The Blockcerts[43] standard and the associated open source project, introduced by the MIT Media Lab in 2016, represent the prototypical implementation of this system. Blockcerts is Open-Badges-compatible in terms of DC content and was developed together with the company Learning Machine[44], which also presented a Blockcerts-compliant wallet app for mobile devices in 2017. Both standard and app remain in active development[45].

A selection of European and global DC blockchain projects with German participation was recently described comparatively, in the context of common challenges (Bertini et al. 2021) – among those **DigiCerts**, with eight partners in Germany and one in Austria, and **EduCTX**, with three partners in Slovenia, Czechia and Germany. A related project is **QualiChain**, with two German and ten more partners in Greece, the United Kingdom and Portugal. Further, the Greek Universities Network (GUnet) is currently developing the **eDiplomas** platform with services for universities, students and public authorities[46]. While these projects are primarily concerned with higher education certificates, two other networks were established in Germany in 2020: The **Netzwerk Digitale Nachweise** (see section 2.2) focuses on blockchain-verifiable school certificates, while **Cert4Trust** deals with certificates for vocational training. The founding members of Cert4Trust are the two Chambers (see above) IHK and HWK for Munich and Upper Bavaria, respectively, the City of Munich, and the Bavarian State Ministry of Digital Affairs. The basic concepts and technologies behind all these projects, as described above, are very similar. However, differences lie in the blockchain frameworks and the associated concepts used, e.g. concerning roles and permissions or tracking DC validity over time, as well as in the extent to which related topics such as identity management or data protection regulations are addressed in each case (Bertini et al. 2021). Some systems of this kind are already being actively used by university networks in other EU countries, for example, **DiploMe** in Italy (see section 2.3) or the Spanish network **Blockchain Universidades Españolas**[47] (BLUE). In addition to start-ups and spin-offs in Germany, such as CertoTrust, kilt.io and TrustCerts (whose product is already used for issuing DC by e.g. the FOM group of private universities), there currently exist at least 20 similar providers across the EU, some of which with a range of educational institutions as customers. Examples include BCdiploma in France, sproof.io in Austria, Diplomasafe in Denmark, as well as Credentify and gradbase in the United Kingdom. As of November 2020, a list[48] provided by the U.S. Department of Education that collects blockchain-DC projects and products worldwide contains 75 entries.

42 The simplified description of blockchains as databases seems sufficient and appropriate in the context of this article.
43 https://www.blockcerts.org [02/15/2021]
44 Learning Machine has since been acquired by Hyland and rebranded Hyland Credentials.
45 https://www.hylandcredentials.com/badges-and-blockcerts [02/15/2021]
46 https://priviledge-project.eu/news/ediplomas-platform-reaches-new-heights-in-greek-legislative-policy-and-digital-transformation-of-higher-education-institutes [02/15/2021]
47 https://tic.crue.org/blue [02/15/2021]
48 https://usedgov.github.io/blockchain/directory [02/15/2021]

3.2 Conceptual focus Badges

Badges are compact digital images that are suitable for displaying a person's competencies and achievements, as certified by third parties (see e.g. Clements et al. 2020; Buchem et al. 2019). Among the other DC data standards described above, the underlying Open Badges[49] standard stands out for two reasons: First, it has existed since 2012, with more than 40 million badges issued worldwide to date[50], and second, it is so far the only standard that has gained an audience beyond the circle of "DC enthusiasts" and experts. The main reasons for this are, presumably, the highly intuitive form of visual representation as well as the lively ecosystem that has grown around private-sector badging solutions (see below). Originally developed by the Mozilla Foundation, the Open Badges standard has been managed by the IMS Global Learning Consortium since 2017. The latter is a non-profit organization of currently over 400 educational institutions, political stakeholders and software providers distributed worldwide, with the main goal of developing and establishing data standards in the field of learning technology. An Open Badge consists of the actual badge image and machine-readable DC data. Commonly, the latter is invisibly integrated into an image file.

In Germany and Europe, the interest in the use of badge DC picked up speed from around 2014, for example in the early projects "**Beuth Bonus**" at Beuth UAS Berlin[51] and "professional MOOCs" (**pMOOCs**) at UAS Lübeck. A project entirely focused on badges started in 2015 in Italy, the **Bestr** platform (see section 2.3). In addition, various badge projects have been funded by the EU in recent years, such as the "Open Badge Network" (**OBN**[52], until 2017), "Open Badges for Adult Education" (**OBADE**[53], until 2018), "Open Badges to Validate Youth Work" (**BADU**[54], until 2019), "Aligning Badges, ESCO and the Certificate Supplement" (**ABECS**[55], until 2020) and "Open Virtual Mobility" (**OpenVM**[56], until 2020; also linking badges to ESCO). In some cases, recurring partners are observed: Beuth University, for example, was the coordinator of both OBN and OpenVM, while DUO from the Netherlands was involved in both OBN and ABECS.

Both organizations are currently consolidating their badge commitment: DUO in the context of **EduBadges** (see section 2.3) and Beuth University both within new externally funded projects and in its own long-term project **Beuth Badges**[57]. Altogether, the projects mentioned above may only represent a small selection: A search with the term "Open Badges" in late 2020 revealed 52 completed and 59 ongoing projects funded via Erasmus+[58]. Badges are therefore being experimented with in many different contexts.

The interest in badge-DC has also been growing on the private-sector side for several years. The largest international market share is currently held by the Badgr and Acclaim solutions for badge issuance and verification, developed by the US companies Concentric Sky and Credly, respectively. In Germany, their customers include the Deutsche Institut für Marketing and Haufe Akademie, both of which use the Badgr platform to award badges in the area of continuing education[59]. Large international corporations such as Facebook, IBM, Microsoft, Salesforce and SAP use these established badging systems for the same purpose[60]. The Irish EdTech provider Digitary has been in the market since 2005 and now serves a global customer base. Digitary is behind the government developments "**My eQuals**" for Australia and New Zealand, **CHESICC**[61] for China and the recently launched national wallet solution **MyCreds**[62] for Canada; there are additional plans for a platform in Japan. In each of these cases, badges are only part of the functionality. Widespread learning management systems such as Moodle, Blackboard or the German Ilias now also support issuing badges. An example of a completely self-implemented solution that combines badges with large-format DC and detailed information on learning outcomes was recently presented[63] by the Training Center of the International Labor Organization (ITCILO). This will enable ILO-supported vocational education and training projects around the world to issue paperless credentials.

49 https://www.imsglobal.org/sites/default/files/Badges/OBv2p0Final/index.html [02/15/2021]; https://openbadges.org [02/15/2021]
50 http://content.imsglobal.org/badge-count-2020/badge-count-2020 [02/15/2021]
51 From October 1, 2021, the "Beuth" UAS in Berlin will be renamed "Berlin" UAS.
52 http://www.openbadgenetwork.com [02/15/2021]
53 https://www.open-badges.eu [02/15/2021]
54 https://www.badge-badu.eu [02/15/2021]
55 https://www.ecctis.com/Our Work Worldwide/Contributions/abecs.aspx [02/15/2021]
56 https://www.openvirtualmobility.eu [02/15/2021]
57 https://beuthbadges.wordpress.com [02/15/2021]
58 https://ec.europa.eu/programmes/erasmus-plus/projects_en#search/project/keyword="open badges"&matchAllCountries=false [02/15/2021]
59 https://www.marketinginstitut.biz/zertifikatslehrgaenge/marketingmanager-dim [02/15/2021];
https://www.haufe-akademie.de/seminare-lehrgaenge/trending-topics/open-badges [02/15/2021]
60 https://www.insidehighered.com/news/2020/08/27/interest-spikes-short-term-online-credentials-will-it-be-sustained [02/15/2021];
https://training.sap.com/content/certification-verification [02/15/2021]
61 https://www.chsi.com.cn/en [02/15/2021]
62 https://mycreds.ca [02/15/2021]
63 https://www.itcilo.org/stories/introducing-itcilos-new-digital-credentials [02/15/2021]

3.3 Further projects

In addition to those mentioned above, there are further projects driven by educational institutions that can currently be considered pioneering. For example, the issuing of digital university diplomas at the **University of Göttingen** since 2017 is still unique within Germany. In this, a hybrid strategy is used[64]: The certificate documents are first issued in paper form, then signed and scanned before being handed to the student. The scans are stored in PDF format on a verification server with a randomly generated ID as part of the URL; they are further password-protected. The student additionally receives an email with an unsigned PDF version including a clickable link. A reference to the possibility of online verification including ID and password is found on all versions of the certificate. In this manner, third parties can compare the digital version, as provided by the graduate, with the scanned original on the server. On top of the similar, nationwide systems in e.g. the Scandinavian countries and in France (see above), individual institutions in other European countries operate comparable systems.

The **Digital Credentials Consortium** (DCC), founded in 2019, is special for different reasons: With two German partners so far and ten more in the United States, Italy, Canada, Mexico and the Netherlands, it is the first bottom-up DC network with global aspirations. The participating institutions, mostly universities, are among the most renowned in their respective countries. Accordingly, they are heavily involved in international student exchange processes and share an interest in optimizing those. In a white paper published in early 2020 (Chartrand et al. 2020), the DCC partners formulate the shared vision of a unified DC "envelope" – i.e., a data exchange standard, with W3C-VC being favored – and particularly discuss a number of strategic issues that they consider important. These include, for example, international data protection regulations or the question how and by whom a shared DC infrastructure could be maintained long-term. The DCC does not currently focus on growth, even though expansion to other continents is envisaged in the coming years. Rather, the current focus is on developing prototype solutions. The fundamental challenge here is to bridge DC developments that have been running independently for years, for example those in the United States and the European Union (with both increasingly gaining momentum, as described in detail above for the EU). To this end, the DCC is in contact with the Groningen Declaration Network[65], as the largest international association for the exchange of student data (see Christmann-Budian et al. 2018), the IMS consortium, on the topic of Open Badges and others, and the W3C working groups on DC and digital identities.

64 https://www.uni-goettingen.de/en/576086.html [02/15/2021] and the presentation available for download there.
65 https://www.groningendeclaration.org [02/15/2021]

4 Outlook

This review illustrates that the majority of the many ongoing DC projects in Europe – whether national or international, political or technical, overarching or focused – are closely intertwined, both conceptually and institutionally. The core motivation behind the DC idea, facilitating the fast and reliable exchange of credentials, inherently promotes the networking of stakeholders within projects and beyond. This applies, above all, to the topic of shared data standards. The extendable W3C-VC standard is currently emerging as a consensus solution for worldwide use. However, it will only be successful once already established formats, such as Open Badges and ELMO, can either be embedded or converted into and out of it in a routine manner. Only then can the communities and ecosystems that have grown from previous projects and around existing products be taken into account, and not least the many DC already issued. Not doing so would not only be inefficient but also presumably lead to hardly surmountable, and ultimately understandable, resistance from these communities.

Another factor that became apparent in 2020 is an increasing trend toward transparency. For Europass and the German XHochschule, for example, all project progress is made publically accessible in the form of transcripts, presentations and working papers. For this reason, classic "parallel developments" that entirely ignore other ongoing projects and standardization efforts can hardly be observed. Apart from expected similarities in implementation between national projects, such as DC wallets, there is, however, a certain need for consolidation emerging when it comes to blockchain-DC. To this end, the most important findings (e.g. regarding technical implementation) and open questions (e.g. regulatory ones) from the various research projects, the few existing productive systems and, where applicable, from commercial providers should first be collected. Based on this, fundamental decisions on the use of blockchain technology for DC should then be made in a timely manner. Above all, these should address the infrastructural side, i.e., who can and should operate the corresponding nodes long-term. Initial answers to these questions can be expected for the EU level from the collaboration of the EDCI and EBSI teams, and for Germany from the work of the Netzwerk Digitale Nachweise and the IT Planning Council.

In addition to further contributing to international developments, for example through the issuance of EDC-compliant certificates and the submission of learning opportunities to the Europass QDR, European countries can also continue to inspire each other. A variety of examples was given in this regard in section 2.3. While some have existed for quite a while and are often cited as benchmarks, e.g. the early DC efforts in the Scandinavian countries and the Netherlands, there are also more recent, lesser-known developments. In Italy, for example, individual universities have been awarding digital badges for degrees for some time now, an experiment thus far rarely seen worldwide that is equally suitable for institutional "branding" as it is risk-free. France, on the other hand, is working on expanding its national DC wallet. This will allow citizens to use existing online accounts, such as those at banks, to log in. As in Finland and Norway, this can be a way to bridge the wait for a possible citizen's account, such as the one planned for OZG implementation in Germany. Another example is the flexible and creative use of the EMREX "toolbox" by individual states. For Germany and its internal educational federalism, for example, it is still unclear in late 2020 whether there can and will ultimately be a central EMREX NCP (i.e. a single, central database) as implemented e.g. in the Netherlands. In this case, the Polish system, where each participating institution is simultaneously client and server (i.e. NCP) via its SIS, illustrates a possibly feasible alternative, especially since preliminary work on various SIS interfaces is already underway in the PIM-XHochschule project. As a decentralized approach, however, it conflicts with the idea of a national wallet solution or a central module database to some extent. Overall, the different national EMREX solutions underscore that agreement on fundamental workflows and a shared data standard need not preclude diversity. EMREX therefore continues to serve as a model for all future developments.

A current threat to the successful and widespread introduction of DC that is not to be underestimated is posed by "semantic confusion". This refers to the increasing vagueness and obscurity in the use of certain terms, which is often exacerbated in the internal and public discourse among decision-makers. For example, the topics of digital credentials, badges, microcredentials and quality assurance should be clearly distinguished. To begin with, DC, as implemented and advanced in the projects discussed above, refer quite generally to digital, machine-readable certificates – with "credential" referring to a proof. The decisive factor here is the move away from paper. DC can be awarded for learning and examination achievements of all kinds, from a proof of participation in a weekend course to a degree, just like their paper ancestors. This is possible, for example, with all three DC standards currently used throughout Europe: ELMO, Open Badges and W3C-VC including derivatives. Based on the different aims these formats were originally developed for, ELMO has so far been used mainly for the exchange of module data or ToR, and badges mainly to certify the completion of short-format learning opportunities or individually acquired competencies. The new W3C-VC standard, on the other hand, was deliberately designed to cover all use

cases. In the case of the term "microcredential", as it is understood in the MicroHE and MICROBOL[66] projects, for example, and most recently also in the Bologna Process (Futures et al. 2020), the emphasis lies on "micro": Short formats are explicitly addressed, whether online or offline. Accordingly, "credential" is used here with its second, more general meaning, referring to a qualification. In principle, any kind of DC, as well as any kind of paper certificate, can be issued for microcredentials in this sense – just as for "macrocredentials", e.g. degree programs. For these reasons, it would be clearer for microcredentials to be called "microcourses" or similar, to avoid ambiguity. Simply put, the format of the learning opportunity is not directly related to the type and format of the credential issued for it. Further, the issue of quality assurance, too, affects all learning formats equally. It becomes particularly relevant whenever prior learning is to be recognized or credited. Microcourses are no exception in this regard, no inherently new challenge, but rather join the long list of existing (continuing) education offerings beyond – and, in terms of scope, below – traditional school, apprenticeship and university degrees. As long as a DC data standard allows for describing learning outcomes in free text or, ideally, in machine-readable form (e.g. via ESCO; see Rentzsch et al. 2020; Rentzsch and Staneva 2020), which is the case for all the above-mentioned formats, there is also be the possibility of recognition and crediting later on. Further, again just like universities and degree programs, microcourse providers or individual courses could be accredited for quality by third-party bodies in the future; this, too, was investigated in the MicroHE project. In addition, the "Open Recognition" movement[67] experiments with novel approaches to this topic. For example, individual offerings can be quality-assured by the community (e.g. previous graduates or companies that employ them) through open evaluation or recommendation procedures. All these important points aside, however, it should be emphasized once again: The format and quality of learning opportunities are aspects outside the core topic of DC and do not per se gain additional relevance through their existence. At best, the quantitative increase in online learning opportunities, for which DC rather than paper certificates are commonly issued, increases the pressure on institutions and political stakeholders to establish sustainable processes and specifications addressing these points, not least to support the idea of lifelong learning.

Regardless of the focus of this review on Europe, the worldwide mobility of learners and employees makes it appropriate and important that stakeholders such as the DCC or the European Commission also already network on the DC topic globally, especially with regard to data standards. A central pivot for this are the open and regular meetings of the W3C-VC working group, whose contents – as well as the corresponding mailing lists – can be freely accessed[68], again for the sake of transparency. Another important aspect is the regular exchange within the community via the DC conferences of the Groningen Declaration Network and the IMS Global Learning Consortium, even if the latter still has a strong U.S. focus. Both at the national and international levels, and regardless of the respective conceptual and technical solutions (the diversity of which was the main topic here), there is one decisive factor for the success of the DC idea: How clearly and strongly can the incentives for the three most important stakeholders – learners, education providers and employers – be carved out? Especially given the many voluntary aspects, which will most likely remain so in the future, a "win-win-win" scenario should be the goal. In addition to the overall more efficient verification of credentials and their facilitated long-term storage, important elements of this are

- making it easier for learners to show and manage their individual achievements, for example in online portfolios and wallets,
- new marketing options for education providers, for example through automated recommender systems, and
- more efficient and more targeted recruiting processes for employers through the simplified matching of jobs and applicants.

At present, DC offer an additional advantage for the provider side that should not be underestimated and that, at the same time, illustrates the need for further progress: As described in sections 2.3 and 3.3 by way of example, issuing digital certificates – especially in the area of traditional "offline education" – still represents a rare and therefore conspicuous selling point in most countries. In view of the wealth of projects presented here, however, this may not remain so for much longer.

66 https://microcredentials.eu/about-2/microbol [02/15/2021]; https://eua.eu/101-projects/782-microbol.html [02/15/2021]
67 https://www.openrecognition.org [02/15/2021]
68 https://w3c-ccg.github.io/meetings [02/15/2021]; https://lists.w3.org/Archives/Public/public-vc-wg [02/15/2021]

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