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HOW CAN EUROPEAN BLOCKCHAIN SERVICES INFRASTRUCTURE BE USED FOR MANAGING EDUCATIONAL DIGITAL CREDENTIALS?

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Research paper

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Abstract

Self-sovereign identity deals with the way individuals can manage their identity in the digital world. This is high in priority for European Blockchain Infrastructure (EBSI) that is leveraging blockchain technology and offers a decentralized solution that enables higher education institutions (HEI) to manage sensitive digital data that shouldn't be forged, such as digital credentials (e.g., diplomas and proofs of studying). This simplifies the way digital credentials can be issued and verified by HEIs while giving the ownership of them to the learner. However, there is an absence of empirical research using EBSI ecosystem for cross-border verification of digital credentials. To address this gap, we used design science research method and developed an artefact. A study between two HEIs was conducted, and the artefact was evaluated through qualitative analysis by interviewing 19 administrators from HEIs. As a contribution, our study identifies 14 considerations that might affect the implementation of such a system in practice. However, we conclude that institutional and national strategies towards digital credentials play a bigger role than technical considerations for implementation.

Keywords: digital credentials, higher education institutions, EBSI.

1 Introduction

Digitalization has had a significant impact on different sectors including education in recent years. Higher education institutions (HEI) are increasingly implementing digitalization of services that enhance learning and teaching such as remote communication tools (Grosseck et al., 2020) but also updating administrative processes with paperless documents, certificates such as diplomas issued to learners (Bacharach, et al., 2021; Lepiane et al., 2019). However, these digitization efforts have also brought out concerns on validation and verification of digitally issued credentials.

Prior literature and large international initiatives highlight interesting new ways to manage educational data (Digital Credentials Consortium, 2021; European Commission, 2020; RMIT, 2021). Self-sovereign identity (SSI) is proposed as a solution to give the users control over all of their data including identity (Allen, 2016; Pöhn et al., 2021; Tobin & Reed, 2016) and educational credentials such as diplomas (Queirugaa-Dios et al., 2022; Sedlmeir et al., 2021). European Blockchain Services Infrastructure (EBSI) is a large-scale initiative by the European commission which leverages the blockchain technology and enables institutions to issue verifiable credentials for various purposes including educational credentials such as diplomas and micro-credentials (EBSI, 2022). Learners can store these verifiable credentials in a digital wallet and have complete control over them as to who and when to share them (Sporny et al., 2019). The main value proposition of EBSI is to simplify the way digital credentials can be issued, managed, and verified by higher education institutions while giving the ownership of them to the learners.

The recent increase in the discussion around micro-credentials has also contributed to the need to issue different forms of digital credentials in higher education, such as diplomas, certificates, or badges (Ahmat et al., 2021; Oliver, 2019; Pirkkalainen et al., 2022). From HEI perspective, in this paper, digital credentials and verifiable credentials are used synonymously. The emphasis on micro-credentials and interest by learners of all ages including traditional students, lifelong learners (for upskilling and reskilling) to take micro-credentials makes it even more important for HEIs to have a system for cross-border verification and validation of digital credentials. Most of the research on digital credentials (including badges) has focused on how they are issued (Ghasia et al., 2019; Hickey & Chartrand, 2020) and used (Iwata et al., 2019). Very little research focuses on the ways how blockchain (e.g., EBSI) can support organizational processes within organizations or HEIs to manage digital credentials. Specifically, empirical studies are missing for evaluating EBSI for cross-border verification and validation of digital credentials. The objectives of this study are:

(1) To design and develop a blockchain-based solution as proof of concept for managing cross-border digital credential exchange.

(2) To evaluate the feasibility of implementing such solution(s) for higher education institutions' utilization

To address the above research objectives, we take a Design Science Research Methodology (DSRM) approach (Peffers et al., 2007; Hevner et al., 2004). DSRM (Peffers et al., 2007) is used to design EBSI-based IT artefact for managing digital credentials. The solution was evaluated with interviews with administrators of HEIs, development logs and EBSI literature. This study contributes to information systems (IS) literature with an improved understanding of blockchain infrastructure utilization, and in practice to educational technology community to build better services and solutions for HEI processes. The rest of the paper is organised as follows: In section 2, we cover research methodology followed by presenting the related work in section 3. In section 4, we describe the design and development of an artefact for issuing micro-credentials using EBSI framework. In section 5, we share the demonstration and evaluation of the artefact followed by discussion and conclusion in section 6.

2 Research methodology

We chose to follow DSRM approach (Peffers et al., 2007) for this case study. DSRM allows us to address unsolved problems in an innovative way leading to artefacts that can be evolved further (Hevner & Chatterjee, 2010). The artefacts could be a model, construct, or a better method (Baskerville et al.,

2018). DSRM is also a way to question existing structures and processes, and not just the technical implementation (Pirkkalainen, 2015). The main DSRM phases (Peffers et al., 2007) start with (1) identifying the problem and motivation, (2) defining the objectives for developing a solution, (3) designing and developing, (4) demonstrating, (5) evaluating the solution. For this study, the design and development phases are carried out by developing an artefact and demonstrated through a case study between two HEIs in two different countries. For evaluation, we used, (a) semi-structured interviews with administrators, (b) development notes and logs of EBSI, and (c) literature in understanding if this proof-of-concept system can be scaled to production and used by the institutions.

Qualitative data collection and analysis:

19 individuals in administrative roles were interviewed from 11 universities to understand the feasibility of implementing such a cross-border digital credential scenario in practice. The two institutions who participated in this case study are also included in the interviews. Six women (31.5%) and 13 men (68.5%) were interviewed. The interviews were conducted between February and June of 2022 and lasted between 28 and 63 minutes, with an average of 52 minutes. The interviews were conducted remotely using Microsoft Teams and were recorded with the permission of the participants. The focus of the interviews was to understand if a system like the proof of concept built here can be used in their own institutions to issue digital credentials. The roles of administrators ranged from project managers to head of services in educational leadership in the institution. The administrators were aware of the micro-credentials, what is needed to be done at institutional level to use such a system as the artefact built.

All the interviews were transcribed. We chose to use interpretive study for our qualitative analysis (Sarker et al., 2018). Data were labelled, and similar answers were grouped together until patterns emerged. The emergent themes were then placed into two data-driven categories, technical and organizational considerations affecting the feasibility of EBSI implementation. During the entire process, we continuously reflected on the findings in the context of previous research.

3 Related work

Blockchain and EBSI

The use of blockchain based systems in the HEI context has gained increased attention recently due to its unique features such as decentralization, verifiability, and privacy (Vidal et al., 2019). Blockchain's distributed ledger characteristic provides a significant advantage for HEIs as it eliminates the need for a trusted third party to perform verification. Extant research highlighting blockchain solutions for higher education shows various benefits including transparency, increasing human resource effectiveness, extending the digital credentials to include short learning experiences such as micro-credentials and even facilitating student mobility (Raimundo & Rosario, 2021). The blockchain mechanism relies on several nodes that are linked in a peer-to-peer network of participating entities thus making it decentralized and harder to modify or forge documents. Anyone looking at the transactions would not be able to read any personally identifiable information thus protecting student privacy (Grech & Camilleri, 2017). Standards such as Blockcerts (MIT, 2016), and platforms such as EduCTX (Turkanović et al., 2018) were developed to issue and verify academic records with blockchain as the underlying technology. Digital credentials along with digital wallets provide learners with a secure and portable alternative to physical certificates. Blockchain technology promises to be a potential tool to achieve the SSI goal (Alexander et al., 2019; Grech & Camilleri, 2017) by creating a decentralized and distributed environment making the digital credentials immutable and portable.

Extant research on blockchain technologies in the HEI context has mainly focused on the technology's application areas and potential in general (Awaji et al., 2020; Grech & Camilleri, 2017). There is limited research available on constraints and issues with blockchain protocol level (Rossi et al., 2019) and on the barriers and challenges of using blockchain in higher education (Kamišalić et al., 2019; Park, 2021; Steiu, 2020). Even at the blockchain level, very limited research is available on aspects that affect its

the adoption by HEIs (Li et al., 2022; Mohammad & Vargas, 2022) that covers technological barriers with a few environmental and organizational issues covered. There is a lack of research done on wider organizational concerns and aspects that will hinder such adoption.

EBSI is designed to deliver cross-border services deployed on a blockchain network with nodes distributed across the European Union. EBSI is an initiative from the European commission and at the heart of it is to implement SSI in Europe allowing users to create and own their identity and data across borders (EBSI, 2022). EBSI developed several frameworks to address different use cases including digital credentials for verification. These digital credentials can be used for different cross-border scenarios including education, social security, and identification. EBSI uses W3C Verifiable Credentials data model (W3C VC, 2022) for creating a set of tamper resistant claims with specific properties set for each claim (Laborde et al., 2020). For HEIs, solutions such as EBSI which offers the combination of digital credentials and blockchain can not only provide advantages such as trust and immutability, but also facilitate administrative processes in verifying the credentials (Kamišalić et al., 2019). Whether the verification needs to be done for the credentials issued by own institution or validate the credentials issued by other HEIs, EBSI ecosystem can help with its Issuers Trust Model and Decentralised Identifiers (DID) methods (EBSI, 2022).

A few pilot projects using EBSI for cross-border use cases have surfaced in recent years including issuing verifiable ID for citizens, issuing diplomas for university graduates and municipality credentials, all focusing on the importance of managing personal data and immutability. One such use case was for sharing health care data across the EU using EBSI (Bittens et al., 2021). Studies on EBSI have focused on proposing a reference model architecture (Turkanović & Podgorelec, 2020) and converting or extending existing digital credentials to be SSI compliant using EBSI (Buchanan et al., 2022; Herbke & Yildiz, 2022). Some of the research focuses on how EBSI can help students with skill certification (Azan et al., 2022) and student mobility (Strack et al., 2022). However, there is no empirical research done so far with EBSI system specifically for micro-credentials.

Therefore, this paper aims to address these gaps in research by uncovering the wider organisational issues as well as technological issues specific to EBSI and as an extension to blockchain technology that might affect adopting such a system on a wider scale. In addition, this paper will help academics, administrators, and policymakers interested in gaining knowledge about this technology as well as barriers that need to be overcome to promote its wider use.

4 Design

Developing a system with new technologies and integrating them with existing systems always encounters challenges both technical and organisational. The objective is to understand what it takes to build and adopt a system like EBSI to issue digital credentials. What standards such as data models are available to use and do they meet all the needs for issuing micro-credentials. What are the different criteria that might impact such adoption. Is it feasible for institutions to adopt systems such as artefact built on EBSI framework easily into production? Is it easy to integrate with existing systems and if not, what are the factors that might impact?

The main objective of this artefact is to understand how the information flow works in EBSI ecosystem and components that need to be developed for this interaction. Information flow occurs between all the three actors, (a) holder – who has a digital wallet to receive, accept and share digital credentials, (b) issuer – who can issue digital credentials and (c) verifier who can verify the digital credentials that holder presents.

4.1 Artefact development and demonstration

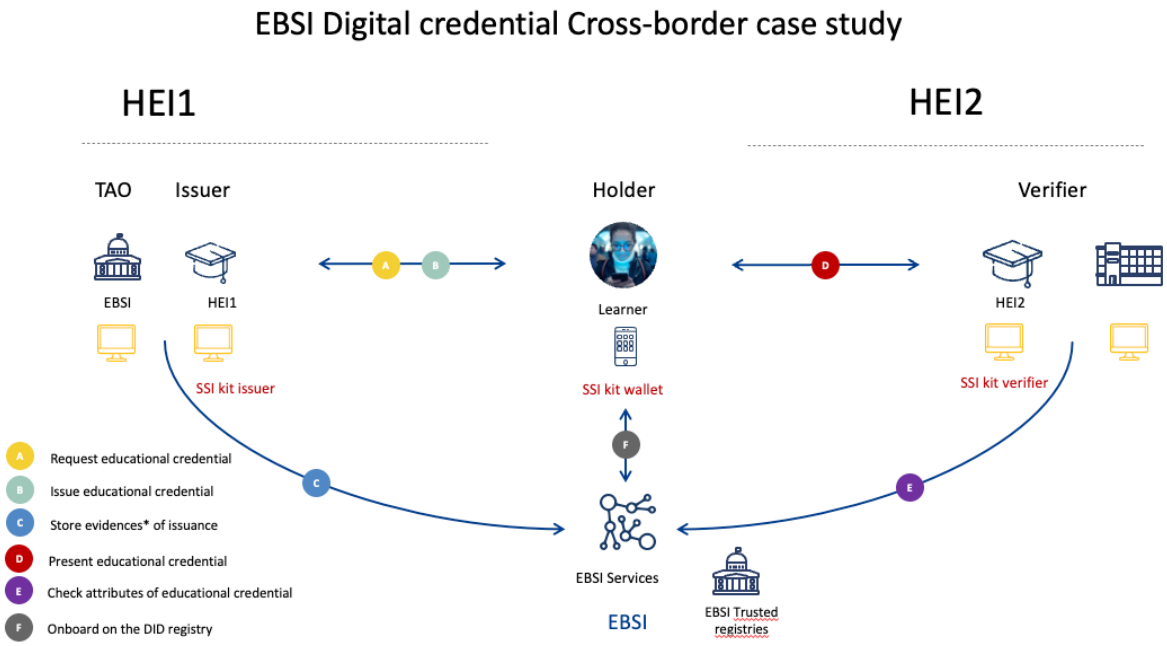

Figure 1 – EBSI information flow (credit: EBSI, 2022)

The artefact built revolves around the 3 actors with the roles of (1) holder, (2) issuer and (3) verifier (Figure 1). The system consists of a web wallet for the holder and two portals (issuer and verifier) for both institutions. In this artefact, issuer portals for both institutions could issue academic IDs and digital credentials. Verifier portal for both institutions could verify digital credentials issued by their own institution or by the other. In addition, the verifier portal for HEI2 could also verify academic IDs as required for the case study. Standard EBSI flows were used for communicating with the wallet for issuing verifiable digital credentials as well as for verification of presented credentials. The wallet as well as the portals were accessed through website.

An open-source solution provided by Walt.id, a company specializing in identity and trust in the web was used in development of this system. Development of issuer and verifier were done by both HEIs representing their own institution. The wallet for the holder was an unmodified version of the walt.id web wallet hosted by HEI1 although in practice, wallets are not hosted by institutions. Issuer and verifier portals for both institutions were based on the reference implementation by Walt.id. Issuer and verifier portals were combined into a single student portal by each institution and customized for their part in the case study. The web wallet and the student portals were all part of the walt.id Wallet Kit1.

The browser-based frontends of the components were implemented with the Nuxt web application framework, which in turn was based on the Vue web user interface framework. These frontend applications then use a server-side backend via a RESTful HTTP API. For simplicity Walt.id implemented all the backend functionality needed by the frontend components into a single server application called Walt.id wallet backend. It was implemented using the Kotlin programming language in the Javalin web application framework.

EBSI and verifiable credential related functionality in the backend, Walt.id SSI Kit2 was used including creating, issuing, storing and verifying digital credentials. It was also used to handle the storage and use of cryptographic keys and communication with the EBSI services such as the DID registry. Although it was a software library, it could be used via command line or as a web service.

Adapting the Walt.id demo portals to our case study required changes to both frontend and backend software. Once the issuer and verifier frontends were combined into a single application, modifications were made to simulate a real student management system and the workflow was adjusted as required for the case study. In the case of HEI2, the workflow was more complex as it involved additional steps of (1) to verify the academic ID issued by HEI1 and (2) to verify the micro-credential submitted by the learner as a prerequisite and (3) to simulate the learner registering to a course. Modifications required at the backend included listing the correct available credentials, creating the appropriate credentials, and verifying the credentials including checking for proper accreditation of the issuer from the EBSI trusted issuers registry. For issuing the digital credential, HEI1 modified the backend to automatically convert the Excel file containing European Digital Credential (EDC) into EBSI compliant verifiable credential as both use the same W3C verifiable credentials data model. While developing the artefact, code contributions were made to the Walt.id open-source wallet and the SSI Kit verifiable credentials library to add proper support for the EBSI verifiable diploma schema used in our micro-credentials.

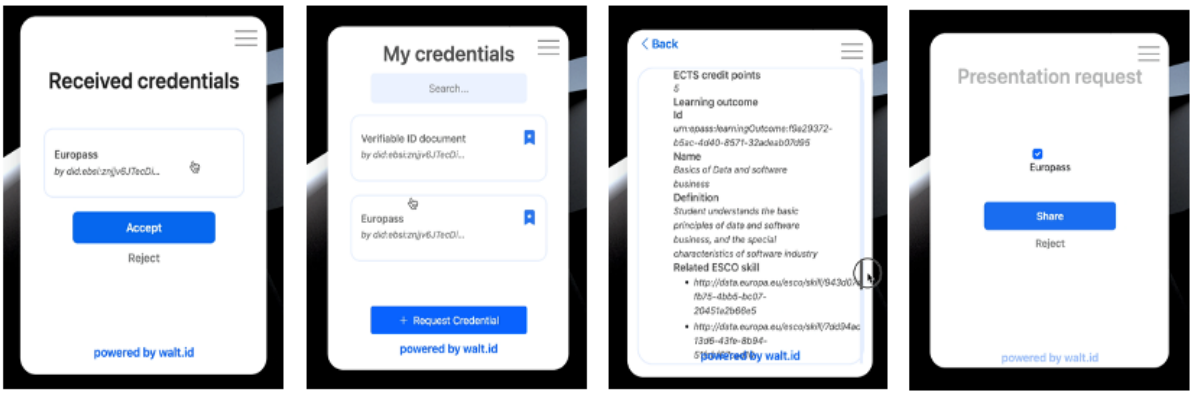

Figure 2 – Wallet views – receive credential, list of credentials, details of credentials and sharing a credentials

Figure 2 shows wallet user interface (UI) for four significant steps. First, when the learner received the credentials and given the option to either accept or reject it. The second one shows the list of all the digital credentials learner requested and received including academic IDs. The next one shows rich metadata included into the digital credential showcasing specific use of the system for micro-credentials. And the last one is when any of the digital credentials are shared from the wallet using the presentation UI.

4.2 Demonstration - Case study with two universities

The case study is done to demonstrate a cross-border scenario between two HEIs in two different countries. Learner is a fictional student in a PhD program at HEI1. Learner manages her digital identity by creating a wallet through EBSI compliant agent. Through the wallet, she can request for credentials, receive, accept or reject them, view and share the credentials.

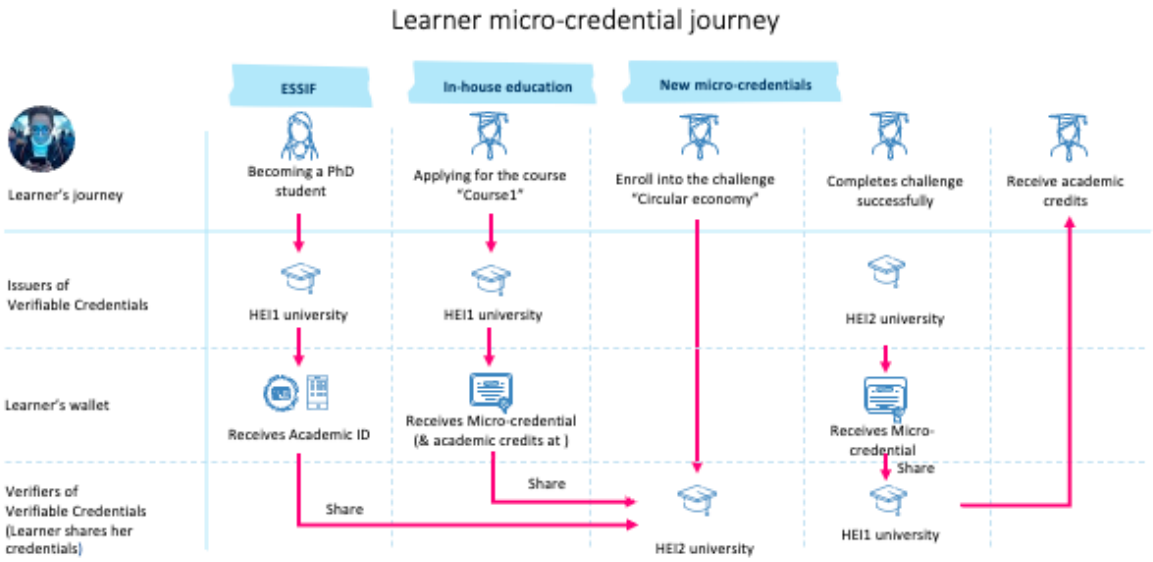

Figure 6 – Learner micro-credential journey (credit: EBSI, 2022)

The case study represents a cross-border scenario with another institution in a different country. The flow of information in this case study includes (Figure 6)

(1) Learner requests and receives her academic id from her institution, HEI1.
(2) Learner views and accepts academic id into her EBSI complaint digital wallet.
(3) Learner registers for a micro-credential "Course1" from her own institution and receives a digital credential upon successful completion.
(4) Learner receives and accepts the digital credential from her institution for the above micro-credential.
(5) Learner finds an interesting micro-credential "circular economy" at institution HEI2 in a different country.
(6) Learner shares her academic ID with HEI2 to prove her identification.
(7) Learner shares her "Course 1" digital credential with HEI2 institution to fulfil prerequisite for the "circular economy".
(8) Upon successfully completing the micro-credential, she requests and receives a digital credential from HEI2 institution.
(9) Learner views the digital credential in her digital wallet and accepts it.
(10) Learner then shares this new digital credential with her own institution (HEI1) to get academic credit.

5 Evaluation

During the development of artefact and all through the case study, continuous evaluation was done with (1) literature available on the technologies, and semi-structured interviews with administrators in the higher education institutions. The evaluation was done to understand the feasibility of building such a system into production from both technical and organizational points of view. The summary of it is that technically, it is possible but still need the technology to mature and cover some key issues such as all aspects of GDPR. Organizationally, the integration to daily processes of an entire institution is less likely especially in the short term. The findings show several impact criteria due to current technology, the current status of micro-credential adoption as well as other organisational aspects. These are summarised in Table 1 and discussed below.

Table 1 - Considerations for feasibility of implementing the system in practice.

Category	Consideration	Description	Source	Severity for implementation	Explanation
Technical	EBSI node strategy	Members of the European Blockchain Partnership (EBP) have to commit support including creating and operating an EBSI node following the guidelines for GDPR compliance.	ESSIF documentation (Du Seuil, 2019), literature (Buchanan et al., 2022)	High	This becomes a national strategic decision of each country as the EBSI node is operated at national level.
Technical	GDPR compliance	GDPR compliance includes not storing personal data and have right to cancellation of one's own personal data.	EBSI documentation (EBSI, 2022), literature reviews (Mecozzi et al., 2022; Poelman and Iqbal, 2021)	High	Data stored such as personal information can be made GDPR compliant by following a set of procedures. Currently, some rights such as the "right to be forgotten" are not possible with the underlying blockchain technology.
Technical	Accreditation to be an issuer of verifiable credentials	Each HEI needs to be in EBSI trusted issuers registry and their entry there should contain the accreditation VC the (trusted accreditation organisation) TAO issued. TAO can be their national entity such as the ministry of education or EQAR if that entity is registered in DEQAR already.	EBSI and EQAR documentation (EBSI, 2022), artefact	Medium	Not all institutions or the national entities that can act as TAO in each country are part of EQAR and might depend on national strategy and interest in setting this up.
Technical	Using W3C Verifiable Credentials standard	Data model used for a set of claims and properties of each claim in a verifiable credential	W3C documentation (W3C, 2022) and administrator interviews	Medium	If there is a project at national level underway, it requires national strategic decision and work towards interoperability with EBSI.
Technical	Digital Wallet choice for learners	Learners need to have a digital wallet to request, manage, share their credentials	EBSI documentation (EBSI, 2022), literature review (Jørgensen and Beck, 2022), artefact and case study	Low	The concept of universal wallets and interoperability is ongoing. Standardization of data model (W3C VC) and blockchain frameworks will help lead to wallets interoperable irrespective of underlying architecture
Technical	Verification and validation including eSealing	Verify if the digital credential issued is valid both for information and for issuer	EBSI (EBSI, 2022), artefact and case study	Low	EBSI framework makes it easy to verify the issuer, and blockchain technology assures the immutability of the credential. If cross-border issuing requires, adding eSeal is easy, as the data model has the capability.

Category	Consideration	Description	Source	Severity for implementation	Explanation
Technical	Request for credential by learners every time they complete a micro-credential	With SSI, control over data lies with the learner, so the request needs to be initiated by the learner	EBSI (EBSI, 2022), SSI documentation (Du Seuil, 2019), and artefact	Low	If the system is integrated with student management systems, automatic issuing of digital credentials when learner requests doesn't add a lot of extra overhead
Organizational	Integration with student management systems – **Institutional strategy**	Issuing digital credentials as the default process in the institution	Administrator interviews	High	Unless institutions make the strategic decision to issue digital credentials for all the learner credentials, integration with student management systems might not be realized.
Organizational	National adoption of micro-credentials	National level strategy on micro-credentials and align digital credentials with national qualification systems	Administrator interviews, literature review (Pirkkalainen et al., 2022)	High	Without a nationwide strategy and support, wider implementation is not possible and will stop at the piloting and experimenting stage.
Organizational	Integration with student management systems – **into IT pipeline**	Getting the integration effort into the pipeline	Administrator interviews	High	Integration effort such as this can be a large endeavour. Getting such a project into the IT pipeline with other high impact projects already in line is harder.
Organizational	Where the digital credentials are issued from	Issued centrally from individual institution or nationwide system	Administrator interviews	High	This goes hand in hand with nationwide strategy and what policy and implementation that strategy defines. A nationwide system to issue any digital credentials centrally is being considered at least in some countries.
Organizational	Integration with student management systems – **amount of work**	Amount of effort needed to integrate with all the student management systems	Administrator interviews	Medium	Even though the amount of effort needed is high, the factors mentioned above are higher in severity whether this system will be implemented full scale.
Organizational	Interoperability with other platforms in use	Some of the institutions already adopted badging systems	Administrator interviews	Medium	Either the current badging systems need to be interoperable with EBSI system using same data model or live with two separate systems.
Organizational	Choosing a commercial solution or using open-source and develop all the individual components	Using open source gives flexibility in customizing the solution, while commercial products give ready to use solution	Artefact, EBSI documentation (EBSI, 2022) and administrator interviews	Medium	The decision to use open source of a commercial product depends on institution and national strategies, financial and technical capabilities and availability

Technical considerations:

EBSI technology is still evolving and building awareness within Europe. For the blockchain technology decentralization aspect to work effectively, multiple nodes need to be in operation possibly in every country that would consider using EBSI framework. From our administrative interviews, it looks like the solution for it depends on each country's strategic decision of using blockchain for higher education and other purposes. Since Decentralised Identifiers (DIDs) are considered as personal information in Europe, saving DIDs is considered to not comply with GDPR. Solving GDPR in blockchain is an ongoing discussion and some of the aspects are resolved yet some of the aspects such as the "right to be forgotten" still needs consideration. The new version of DID from EBSI for natural persons (EBSI DID, 2022; Gataca, 2022) is aimed at resolving these GDPR issues might have other unintended effects such as recovering from losing one's private key. With the new DID version, if learners lose their private key, they will have to request all their verified credentials again as the VCs are tied to the DID when issued.

From technical point of view, we used EQAR as a trusted accredited organization (TAO) since our ministry of education is already a registered member there, but it is also possible to use the ministry of education itself or another national entity as a TAO. Building TAO registry becomes a key aspect in building trust between institutions especially for cross-border use. Using the W3C VC data model, which is a world-wide standard, helps especially with interoperability at international level but might also add additional work in every nation that hasn't adopted that data model already. As digital credentials continue to gain momentum, interoperability of wallets using different frameworks might surface, but might not affect the choice of framework to use by institutions. Although this might not affect the institutional decision to use the system in issuing the digital credentials, the fact that learners have to request each and every credential might become cumbersome for the learners in the long term. Especially as HEIs start offering more micro-credentials, this might be a contention point for learners.

Organizational considerations:

From the organizational point of view, the strategic choice of implementing DCs throughout the institution was found most critical. According to the administrators, most of the organizational factors to consider (Table 1) for wider scale implementation depend on this strategic choice. This includes integration with local student management systems to access data to issue digital credentials. Our interview data shows that there are nation-wide discussions especially regarding micro-credentials happening at the moment and institutions at individual level might be waiting for a nation-wide strategy to evolve before implementing these solutions. Our findings show that some countries already use nation-wide systems for student and learning management. Moreover, some of the countries are currently working on a national strategy to integrate student and learning management systems for all institutions within the country into a central system. These suggest that implementing the system to issue digital credentials at institutional level might not be feasible and depend on the national strategy, and timeline and so we gave the impact severity high.

"*we are getting ready for cross -institutional studies in XX national service, and we are now starting to adopt it. The universities IT systems are quite soon at the level where they will have automatic processes set up. When a degree student takes some courses in other universities and comes back, they will have the credits already to their home university automatically….. Now that we are developing ways to transfer this data to multiple services, there is a good chance we can also make integration for European systems at national level. Each university doesn't have to do it by themselves as we gather all the data into one place nationally, we can make one integration*" – Senior specialist, educational services.

Our findings also suggest that depending on the maturity of micro-credential adoption within the nation, institutions will end up issuing paper certificates along with digital credentials if implemented today, which would duplicate the work. Since issuing credentials in two ways (current method and digital credentials) might be a short term till more institutions adopt and accept, we considered this factor severity to be medium.

"*Probably in many universities, they ask for paper, with a stamp and manual signature. Probably in some of them they might be accepted, but most of them not yet. Right now, even our university doesn't accept them*" – Project manager for DC and admissions officer.

One of the administrators commented that currently any development effort to integrate with student management system might not even be possible due to other high priority projects underway. Since integration to local student management and/or curriculum management systems is already identified as a major development work, any major projects already in the pipeline might need to be factored in for consideration of such integration.

"*there is a big development going on in the student management system regarding accessibility. There is a big rework being done currently to meet regulations for that feature and perhaps take large part of development resources this year and follows to next year as well. Even if some feature is relatively small, but it doesn't fit into the development roadmap*". – Senior specialist, educational leadership.

Once these strategic decisions are done, consideration needs to be given to whether to use open source technology and custom develop the implementation or go with a commercial solution which reduces development time. The effort required to integrate the solution remains mostly the same, irrespective of the solution being open source or commercial. Our findings from interviews suggest that institutions are currently testing multiple options including alternatives to EBSI as well as commercial solutions before deciding.

6 Discussion and conclusion

The purpose of this study was to evaluate the artefact built on EBSI ecosystem to explore the factors that will hinder the feasibility of implementing it in practice. A total of 14 considerations were uncovered, divided into two categories, technical and organizational. In the technical category, two of them are high in severity, while 4 of the organizational factors can have high severity in realizing such a system in practice. Our findings on considerations augment the literature on institutional perspective. Our study adds to the understanding of the drivers that might affect the implementation of such systems on a wider scale.

6.1 Theoretical contributions

Our first key contribution is the empirical validation of EBSI use for managing educational digital credentials, and is specifically for EBSI literature. Our artefact and case study demonstrates that implementing such a system is feasible technically, provided the factors uncovered by our findings are addressed. Some of the technical factors such as need for EBSI node, and GDPR compliance support the previous studies (Mecozzi et al., 2022; Van Eecke & Hale, 2018). However, our findings extend the current literature showing the impact of these factors goes beyond the technology or the institution itself. For example, the need for an EBSI node at a national level is not an institution's decision or capability but rather a national strategy and commitment to create, operate and manage such a node. This is a significant insight, not only for higher education institutions but also for national agencies whose commitment is needed to realize these solutions and EBSI to realize the wider commitment needed from a country for individual institutions to implement such a solution. The empirical validation also contributes the design knowledge (Baskerville et al., 2018) of EBSI implementations.

This is our second key contribution to IS literature on institutional strategies in implementing a digital credentialing system such as EBSI. Current studies (Chakroun & Keevy, 2018; Selvaratnam & Sankey, 2021) confirm with our findings that there is a need for a strategy at national level and even global level. Most of the institutions and countries are currently piloting or issuing digital credentials at a much smaller scale or as part of a consortium (Turkanović et al., 2018; EBSI, 2022) without full scale integration into their student and learning management systems. There is a consensus among the administrators interviewed for this study regarding the effect of institutional and even national strategy in considering implementation of such a system in practice. And they are interlinked with each other. Institutional strategy often goes hand in hand with national strategy and policies. If the national strategy is to issue

digital credentials from one central system, or use a particular platform, all the institutions follow suit. Our findings suggest institutions are currently awaiting to understand their national strategies before undertaking such implementations.

Our third key contribution to IS literature comes from identifying the adoption related factors for implementing EBSI solutions in higher education. Similar to studies on blockchain (Mohammad & Vargas, 2022; Park, 2021), complexity of integration was considered as a major factor by the administrators. However, our findings suggest it goes beyond just the technical aspects of integration itself. In some cases, the IT pipeline might already have major impact projects lined up for the short-term and adding one more major project such as integration and implementation of this system can be unrealistic. Adding to that, if the institutions already implemented any digital credentialing system such as badging systems, interoperability between both the systems also needs to be taken into consideration.

6.2 Practical contributions

This study makes several practical contributions that will be discussed separately for different audiences.

Higher Education Institutions:

Our findings focused on how higher education institutions can take a proof of concept into realization. From our study, HEIs can understand the factors that will affect such an undertaking and focus on the aspects that need their attention the most. For example, paying attention to the national and international scene on micro-credentials and digital credentials to understand and align the interests. HEIs who are interested in using EBSI system can also initiate/participate in discussions at national level as it requires effort and co-operation at that level, such as creating and operating an EBSI node. By understanding the different organizational considerations to integrate such a system into local student management systems, HEIs can prepare and succeed.

EBSI developers and community:

Although the artefact is developed using EBSI ecosystem, evaluation was done from the perspective of realizing it in practice by HEIs. By understanding the different factors that are in the play, EBSI can help mitigate some of the technical barriers and provide guidance and support to HEIs. By realizing that for any individual institution to realize such a system might depend on a national strategy and policy, EBSI and EU policymakers can help individual countries to understand and provide support. EBSI can help educate the importance of using standard protocols such as W3C VC and blockchain framework to product developers, thus helping to integrate those products into EBSI implementation easier.

CIS/LMS developers:

From our study, one of the key aspects that might hinder the feasibility of such a system is integration with institution's local student/learning management systems. By understanding these factors, management systems and student information systems developers can investigate the possibility of providing interfaces to integrate these systems. They can even consider implementing some of the features required to issue digital credentials built in, making it easier to integrate the systems.

6.3 Limitations and Future research

There are some limitations with our present study. One of the limitations is that the EBSI artefact couldn't be implemented with real user data. Although the proof-of-concept allowed us to evaluate the feasibility of the solution, upcoming studies should explore production-versions of EBSI with real student data. In addition, not all administrators who participated in the interviews have been exposed to EBSI. However, each administrator comes from an institution who are also investigating into the possibility of issuing digital credentials. This is why they fit the study well. We also believe that in addition to technical studies, investigation of strategies and policies on digital credentials at national level is crucial for cross-border use. In addition, the artefact focus was on issuing digital credentials for short learning experiences, i.e., micro-credentials and not for any other credentials such as diplomas or student IDs which might also uncover other factors. We recommend further studies expanding the artefact to include other types of digital credentials that HEIs can issue to get a broader understanding.

6.4 Conclusion

The purpose of our study was to design and develop an artefact using EBSI ecosystem and evaluate the feasibility of implementing it. With the help of administrators from higher education, several considerations that might affect the feasibility were uncovered. The findings indicated that the institutional as well as national strategy plays a big role in realizing such a system into production. These include micro-credential adoption at national level, institutional strategy on issuing digital credentials on a bigger scale. We believe our analysis can enable discussions at institutional and national level on digital credentials, as some of the features of implementation require national level support and commitment.

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