Shaping the educational landscape: the rise and potential of Verifiable Credentials in higher education

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Abstract: *In an era defined by rapid technological advancement, virtually every facet of society has undergone transformative changes. One of the most profound transformations has occurred within the realm of education, where technological innovations have revolutionized the learning landscape. This paper seeks to depict the immense potential held by Verifiable Credentials within the educational system and to unravel their multifaceted applications, positioning them as the vanguard of modern education. Additionally, the paper aims to examine the impact, challenges, and benefits arising from the infusion of this technology into the educational domain and to envision the forthcoming perspectives of this 'partnership' between technology and education.*

Keywords: New technology, Verifiable Credentials, Higher Education, International initiatives, Future Developments.

1. Introduction

Over the last decade, technology has brought about substantial advancements in various sectors, including education. The COVID-19 pandemic further accelerated the adoption of technology in education, leading to a transformation in learning paradigms. This shift has led to the exploration and implementation of new tools and methods aimed at enhancing the efficiency, interactivity, and security of educational processes. In the table below, we can observe the most important technology advancements in education, as well as the essential changes in the educational paradigm due to the pandemic period:

Table 1. Advancements and changes in the learning paradigm and education technologies [own source]

Advancement in Educational Technology	Changing paradigms due to the pandemic
Online Learning Platforms: Learning Management Systems (LMS) such as Moodle, Canvas, and Blackboard have	Remote Learning: Lockdowns and safety concerns led to the rapid adoption of remote learning, prom-

become integral to higher education. These platforms offer a centralized space for course materials, assignments, communication, and assessments.	pting educators to adapt their teaching methods for online environments.
Virtual Classrooms: Video conferencing tools like Zoom and Microsoft Teams have enabled real-time virtual classrooms, facilitating synchronous interactions between instructors and students	Hybrid Models: Many institutions adopted hybrid models, blending in-person and online instruction to accommodate diverse learning preferences.
E-Learning Resources: Open educational resources (OER), digital textbooks, interactive simulations, and multimedia content have diversified the learning experience.	Assessment Techniques: Traditional in-person exams shifted towards online assessments, necessitating the development of secure, proctored online testing solutions.
Adaptive Learning: Personalized learning algorithms analyze student performance to provide tailored content and interventions.	Digital Collaboration Tools: Students and educators started using colla-borative platforms for group projects, discussions, and knowledge sharing.
Gamification: Incorporating game elements into education engages learners and enhances motivation.	

As educational institutions embrace innovative learning tools and strive to enhance the digitalization of their educational frameworks, they are also confronted with significant security challenges. So, technologies as blockchain or verifiable credentials were integrating in order to assure strong and efficient systems that facilitates the interaction between students, educational institutions and other organizations that are requesting educational information.

This paper aims to examine the potential of integrating verifiable credentials into the educational system and environment. It will highlight various instances where this technology has been successfully employed, alongside initiatives that align with its principles. Furthermore, an in-depth exploration of the impact, challenges, and benefits associated with the adoption and integration of this concept will be addressed.

2. Understanding the main concepts

For a better understanding of the advantages of verifiable credentials and a clear view on the utility of them, the main concepts will be presented.

A digital identity is defined as a compilation of attributes that encompass pertinent information, facilitating the recognition and entry of an individual,

organization, or device within a specific context. Managed by designated identity providers, this digital identity paradigm introduces certain challenges related to data sharing and security. Identity owners often employ these identities to secure access or permissions to systems that might not align with established privacy and data sharing standards on the Internet, resulting in an inadvertent excess of information divulgence. This situation underscores the pressing need for a redefined digital identity framework, one that empowers users with comprehensive control over their identity and the intricacies of information sharing (Shuaib et al., 2022).

The concept of self-sovereign identity (SSI) was introduced to empower users with exclusive control over the management of their digital identities. SSI encapsulates three essential elements: individual control, security, and complete mobility. This paradigm deconstructs external controls, entrusting users with the ownership and administration of their data, eliminating the requirement for a centralized external entity to consolidate identities across diverse entities (Vasile & Dinu, 2021).

Christopher Allen, a luminary in security and cryptography, delineated ten cardinal principles underpinning the architecture of SSI (Allen, 2016):

- Existence: The user's societal existence constitutes the foundation of digital identity, anchored in official identifiers such as identity cards or birth certificates. It furnishes the requisite particulars for distinct situations.

- Control: The user retains absolute authority over their digital identity, possessing comprehensive rights to manipulate it, encompassing deletion and updates. This is sustained by algorithms and mathematical methodologies validating data authenticity.

- Access: Users are vested with access to their personal identity information and retain decision-making powers regarding identity-related actions.

- Transparency: The algorithms and systems undergirding the digital identity ecosystem must be transparent, validated, and accessible to the public.

- Persistence: An identity's validity endures for an extended duration, either until the data becomes obsolete or the user opts to relinquish the identity. The rapid evolution of the digital realm necessitates provisions for identity format updates.

- Portability: Identity data and associated services must be portable and accessible, empowering users to perpetually govern their own identity.

- Interoperability: Digital identity systems necessitate global operability and recognition across diverse digital identity types.

- Consent: User consent serves as a prerequisite for sharing or accessing digital identity information. Regulatory safeguards for user safety and privacy must be rigorously observed.

- Minimization: User digital identities must encompass solely the requisite data essential for identification within a specific context. For instance, an event organizer might seek first and last names, obviating the need for disclosing extraneous identity data.

- Protection: In cases of conflict between a user's digital identity and the network managing identities, the user's rights hold paramount significance. Authentication, conducted independently through network infrastructure-independent algorithms, upholds data integrity, authenticity, and persistence.

The main instrument for implementing SSI in the field of digital identity and decentralized identity management is by Verifiable Credentials (VCs). They are a way to digitally represent and prove various pieces of information about an individual, organization, or entity, while maintaining privacy, security, and user control over their data.

To assure the integrity, authenticity, and continuity of data, the implementation of self-sovereign identity management systems is grounded in blockchain technology. The core principle of self-sovereign identity revolves around the management and storage of verifiable credentials residing in off-ledger domains. The credibility of these signed data entities is upheld through the inclusion of a hash on a blockchain. When individuals submit verifiable credentials to a relying party, a comparison of the credential's hash with the accessible blockchain record, authenticated through an integrated signature mechanism, promptly and accurately substantiates the credential's validity. This process expedites the relying party's ability to affirm the credential's legitimacy. In the context of data integrity, a blockchain mechanism facilitates both the revocation of consent-related actions and the maintenance of auditable consent records, thus bolstering the security of data entities (Shuaib et al., 2022).

The concepts presented herein introduce a promising avenue for research and development, delineating a novel sphere in which applications and systems can be conceived to streamline administrative procedures and enhance traditional frameworks, with a specific emphasis on the domain of education.

This emerging field beckons the exploration of pioneering solutions that possess the potential to reshape administrative dynamics and amplify the efficacy of conventional paradigms. Notably, within the educational context, the assimilation of these concepts can herald an era marked by heightened efficiency, interactive engagement, and fortified security.

3. The integration of Verifiable Credentials in higher education

The domain of education is presently undergoing a gradual exploration of the capacities inherent in Self-Sovereign Identity (SSI) and Verifiable Credentials. These innovative technologies have been methodically introduced into various scenarios within the educational framework, with the explicit purpose of scrutinizing and deducing the advantages associated with their incorporation. This purposeful assimilation marks a significant juncture where educators and institutions are meticulously probing the potential of SSI and Verifiable Credentials. Their objective is to uncover new prospects and draw well-informed conclusions regarding the feasibility of integrating these technologies. In the subsequent sections, a range of approaches will be elucidated, shedding light on the multifaceted pathways through which the benefits of Verifiable Credentials are being unearthed and comprehensively comprehended.

Belgium and Italy have jointly leveraged their resources and expertise to conduct action research within a cross-border diploma use case, operating under the auspices of the European Blockchain Services Infrastructure (EBSI) and the European Blockchain Partnership (EBP). The EBSI Diploma Use Case comprises a blockchain-based system that provides a platform for students, educational institutions, and third parties to validate and authenticate educational documents, such as diplomas and certificates, without necessitating a centralized administrative procedure. This validation is achieved solely through the generation of educational credentials. The implementation of this cross-border system for verifying educational credentials was meticulously designed with due consideration for compliance with the General Data Protection Regulation (GDPR) and adherence to the principles outlined by the European Self Sovereign Identity Framework (ESSIF). The overarching objective was to establish the verification of student identification information and transcripts between two prominent universities, namely the University of Bologna and KU Leuven. The primary focus centered on facilitating the seamless exchange of students between these academic institutions. Consequently, two distinct types of credentials were generated and made verifiable: firstly, a comprehensive student ID credential containing all pertinent information, and secondly, a verifiable transcript of records detailing the academic achievements of the students. The outcomes of this endeavor have been demonstrative of noteworthy enhancements in the authentication and verification processes pertaining to students engaged in exchange programs between the aforementioned universities. (Tan et al., 2023).

Digital Credentials for Europe (DC4EU) stands as another pioneering initiative that harnesses the collaborative efforts of Member States to integrate verifiable credentials across several critical domains, including education. The electronic IDentification, Authentication and trust Services (eIDAS) trust framework, a cornerstone within the European Union, provides a foundational basis for establishing identity and trust within the digital landscape. The recent

expansion of this framework broadens its scope beyond identity, encompassing the electronic attestation of attributes (EAA). The formulation of technical measures, procedures, and protocols to establish trust frameworks within specific sectors assumes a pivotal role in fostering a digitally empowered Europe. In light of this, DC4EU is dedicated to identifying and applying these principles within the field of Education. This endeavor will primarily concentrate on the issuance of educational credentials and professional qualifications. Additionally, DC4EU's scope extends into the domain of Social Security, as it actively participates in executing the portable document A1 (PDA1) and the European Health Insurance Card (EHIC). The project's objectives will be realized through meticulous procedures that facilitate thorough testing of wallets. This comprehensive testing will involve the use of Qualified Electronic Attestations of Attributes (QEAA), Electronic Attestations of Attributes (EAA), and credentials. These evaluations will encompass both the national and cross-border functionalities of these elements within a controlled pre-production environment, aligning closely with corresponding use cases (UCs). DC4EU assumes a pivotal role in sculpting a fresh paradigm for citizens in the spheres of education and social security. This role seamlessly aligns with the guidelines articulated by the European Council concerning identity and data. Furthermore, the project steadfastly upholds the principles outlined in the European Declaration on Digital Rights and Principles. Through its partnership network, Romania emerges as an active participant in the fulfillment of the project's objectives. (DC4EU, n.d.).

In their recent work (Koukoularis, Markopoulos & Voutsinas, 2023), the authors introduced a novel model for the exchange of educational credentials. The primary objective was to enhance the process of sharing digital credentials, thereby streamlining diploma verification for purposes such as job applications or post-graduate studies. The model outlines the fundamental principles underpinning the digital diploma platform employed by Greek Higher Education Institutions (HEIs), known as eDiplomas.

The research underscores the significance of a unified Trust Framework as a pivotal factor in achieving interoperability and mitigating the risk of vendor lock-in. The authors conclude by highlighting the imperative for Universities and HEIs to embrace robust and cutting-edge infrastructure, built upon established secure protocols and state-of-the-art privacy-enhancing technologies. This proactive stance is emphasized as critical for sustained success in navigating the evolving landscape of digital innovation.

In the scholarly work conducted by (Strack et al., 2022), an insightful portrayal is provided of the Federal Ministry of Education and Research (BMBF) of Germany's innovative venture. This initiative revolves around the investment in a prototype platform recognized as the National Education Platform, abbreviated as "Nationale Bildungsplattform" (NBP). This endeavor is positioned as a pivotal element within a distributed educational digital service infrastructure. The authors approach this exploration with a dual perspective, emphasizing its centrality from

the vantage point of both the learning user and the decentralized educational service providers (namely, Educational Institutions, Higher Education Institutions, and Private Educational Institutions). The study endeavors to delve into the realm of possibilities and harnesses the potential of various technologies to realize the successful implementation of this platform. By scrutinizing both the user-centric approach and the broader perspective of educational service providers, the authors provide a comprehensive understanding of the endeavor's ambitions and implications.

Examining the limited number of initiatives outlined earlier, it becomes evident that a substantial interest exists in the adoption of educational credentials and the subsequent implementation of blockchain-based systems. These systems are tailored to facilitate the requisite procedures and actions within the educational framework. The momentum behind these endeavors underscores a collective recognition of the potential benefits derived from these advancements in the realm of education.

4. Integration of VCs in romanian education landscape

At the national level, we can admit that there is an interest in developing blockchain capabilities and exploring the concept of verifiable credentials. Between April 2021 and March 2023, UEFISCDI and Politehnica University of Timisoara conducted the European project titled 'EBSI4RO: Connecting Romania through Blockchain.' The project aimed to create an environment that provides knowledge, training, and awareness for adopting distributed technology. Morover, the project supported the participation of Romania in EBSI, by developing an application based on digital credentials and microcredentials for the diploma use case, integrated with (Single) National Student Enrolment Registry (EBSI4RO, n.d.).

In 2021, ICI Bucharest announced a partnership with Selfd.id, developers of the first decentralized platform for digital identity in Romania. The aim of this partnership is to accelerate the digitalization of the public administration systems and alliging with the European initiatives in terms of adopting secure identity technologies (ICI Bucharest, 2021).

Furthermore, the article (Vasile & Dinu, 2021) introduced an informatics system that uses verifiable credentials to authenticate diplomas in correlation with users' identities. This system can pave the way for further opportunities in implementing digital student ID cards, examination credentials, and student qualifications.

5. Impact, challenges and benefits

The impact of verifiable credentials in the education sector has been transformative, ushering in a new era of efficiency, security, and transparency. Verifiable credentials, which are digital representations of educational

achievements and qualifications, have revolutionized the way educational information is stored, shared, and verified.

One of the primary advantages of verifiable credentials is their ability to enhance the portability and accessibility of educational records. Traditionally, paper-based transcripts and certificates were susceptible to loss, damage, or fraud. Verifiable credentials, being digital and cryptographically secured, mitigate these risks by providing a tamper-proof and easily shareable format. This has been especially beneficial for students who are pursuing higher education across borders or applying for jobs internationally, as their credentials can be instantly and securely verified by relevant institutions or employers.

Moreover, the implementation of verifiable credentials has streamlined administrative processes within educational institutions. The manual verification of academic records can be time-consuming and prone to errors. With verifiable credentials, the verification process becomes automated and instantaneous, reducing administrative burdens and allowing educational institutions to focus on more value-added tasks (Kishore et al., 2021).

Additionally, verifiable credentials contribute to the broader concept of lifelong learning. As individuals engage in continuous education and upskilling throughout their careers, these credentials enable a seamless way to showcase their new qualifications and competencies. This, in turn, supports a more dynamic and adaptable workforce.

However, challenges such as standardization, interoperability, and data privacy need to be addressed as the adoption of verifiable credentials grows. Collaborative efforts between educational institutions, technology providers, and policymakers are crucial to ensure that the benefits of verifiable credentials are realized while maintaining data security and ethical considerations.

The impact of verifiable credentials in the education sector has been substantial, ushering in efficiency, security, and adaptability. By modernizing the way educational achievements are stored and shared, verifiable credentials contribute to a more connected and agile learning ecosystem.

6. Conclusions

In conclusion, the integration of verifiable credentials within the education sector signifies a significant stride towards progress. This transition underscores the adaptability of education to the evolving technological landscape, while also exemplifying a pivotal step towards establishing a more secure, efficient, and globally accessible educational system.

Verifiable credentials bring forth three key attributes that warrant attention. Firstly, the utilization of blockchain-based mechanisms for heightened security ensures the preservation of the tamper-proof nature of educational records. This

fortified protection against fraudulent activities safeguards the integrity of academic accomplishments and enhances the credibility of the presented credentials.

Secondly, the streamlining of verification processes carries substantial importance. The agility with which institutions, employers, and evaluators can authenticate credentials accelerates decision-making processes, thereby benefiting both students and professionals. This swiftness holds particular significance in competitive domains such as job applications and academic admissions.

Moreover, the potential of verifiable credentials extends beyond local borders. The ease with which digital credentials can be shared enables individuals to transcend geographical confines, embracing opportunities on a global scale. This capability not only supports cross-border educational endeavors but also nurtures collaborations that bridge geographical and cultural gaps.

However, the effective integration of verifiable credentials hinges on collaboration, standardization, and ethical considerations. The harmonious interaction among educational institutions, regulatory bodies, and technology providers is pivotal to establishing uniform protocols that facilitate seamless data exchange. This standardization fosters an ecosystem where the benefits of verifiable credentials can be fully harnessed.

Ethical contemplations also play a substantial role, particularly concerning data privacy and consent. Striking a balance between the transparency enabled by verifiable credentials and the safeguarding of individuals' personal information requires careful thought and adherence to evolving regulations.

In essence, education's trajectory is veering towards a future illuminated by the potential of verifiable credentials. The commitments to heightened security, expedited verifications, and broadened global horizons hold immense promise. However, navigating this transformative journey necessitates the collaborative efforts of stakeholders to address challenges, align with standards, and uphold ethical principles. Through this collective endeavor, the education sector stands poised to harness the full potential of verifiable credentials, ushering in a new era of recognition and validation for educational accomplishments.

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