



# Unveiling the Potential: Assessing the Role of SSI Wallets in Promoting Sustainability in Federated Learning Environments

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**Abstract:** Quality Education is listed as goal number four among the seventeen Sustainable Development Goals manifested by the United Nations. There exist an endless number of ways to positively influence the quality of education in a given country. This paper proposes how it can be accomplished by unveiling the potential of Self-Sovereign Identity Wallets in federated learning environments such as National Educational Platform. The specific scenario described in this work is based on the research conducted within the project Bildungsraum Digital, funded by the NextGenerationEU and German Federal Ministry of Education and Research.


## 1 INTRODUCTION


“Digital technologies can accelerate achievement of the SDGs but only if governments act now” (Vora and Ingram, 2023). Not only German Government has been proactively advocating for and supporting the United Nations (UN) Sustainable Development Goals (SDG) in general since the beginning (BMZ, 2023), it has also undertaken numerous actions such as a) enforcing digitization within educational institutions by passing new laws (BMI, 2024) and b) funding digitization projects such as Nationale Bildungsplattform (NBP; eng.: “National Education Platform”) (BMBF, 2024), Bildungsraum Digital (BIRD; eng.: “Digital Educational Space”) (DAAD, 2024), eService-Agentur Hochschulen Sachsen-Anhalt (eng.: “eService office for higher education Saxony-Anhalt”) (eSALSA, 2024) and others. This and more has been done in order to provide German citizens with a higher level of education, which directly and positively influences the overall future welfare of a country (Neumann et al., 2023) and, thus, automatically committing to the UN SDG Number 4 for Quality Education. Fulfilling this goal can be accomplished through various means such as decreasing the bureau-

cracy level at educational institutions, abolishing unnecessary print-outs, reducing the number of accounts across various systems i.e. making the data storage more efficient and sustainable. COVID-19 (Coronavirus SARS-CoV-2) pandemics, analogue to a litmus test, allowed to clearly identify major sustainability problems in the federated learning environments. Combating these problems means increasing the level of digitization among Higher Education Institutions (HEI) (Staegemann. et al., 2022) processes.

This work is undertaking another step towards tackling the problem of enhancing the level of sustainability within the federated learning environments. The approach proposed in this paper is to apply Self-Sovereign Identity (SSI) Wallet technology within German universities, in order to simplify the technology usage (lower the entry barrier) in general, improve university processes, decrease the level of bureaucracy as well as to save human and system resources by decreasing the number of accounts compared to a common current set up at HEI.

The underlying paper is structured as follows. Subsequently to the introduction, the second part briefly provides the current state of related research and past findings in the area of using wallets in the federated learning environments. Section 3 in detail introduces the concept and architecture of the BIRD Wallet. It also presents possible use cases

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for sustainable future and how the BIRD Wallet can be integrated within federated learning environments. Thereafter, a possible estimation of the current research's impact is provided in Section 4 along with a discussion and outlook on possible application scenarios for future research. Finally, the paper is summarized in the Conclusion as well as implications on the operating federated learning environments are provided.

## 2 RELATED WORK

This section provides current state-of-the-art in the research related to the usage of mobile wallets in the federated learning environments such as universities as well as on whether and how it affects the sustainability aspect.

The federated learning environment can also be viewed as a federation in which all educational actors come together to form a group (Guo and Zeng, 2020) and provide seamless accessibility to a group of educational services for educational users. For example Project BIRD (DAAD, 2024).

As stated in the Brundtland's World Commission on Environment and Development book by (Brundtland, 1987) social, economic, and environmental dimensions of sustainability are interdependent. It implies that if one strives to improve sustainability by affecting the environmental dimension, the other two dimensions would be affected as well. Substantial research has been done for examining this interdependency.

An empirical study by (Katini et al., 2023) has examined the factors influencing the relationship between the mobile wallet use and the environmental sustainability. The outcome of the study identified that such factors as perceived security, performance expectancy and several others positively impact mobile wallet usage and, thus, contribute towards environmental sustainability. The authors also state that mobile wallet usage would reduce all forms of pollution. However, this paper focuses solely on the mobile wallets used for payments. There have been several attempts towards applying SSI technology in educational domain such as (Kortemeyer, 2022), (Kavassalis, 2020) and (Strack et al., 2022). Additionally, a technical exploration provided by Samenwerkende Universitaire Rekenfaciliteiten (eng.: Collaborating University Computing Facilities) (van Dijk and Rikken, 2023) states that SSI wallet usage offers various advantages for education and research, providing a proof of concept.

### 2.1 Sustainable University

Sustainable universities play a pivotal role in advancing Sustainable Development, with HEI assuming a distinct social responsibility for shaping future leaders' education and fostering widespread public awareness of sustainability (Amaral et al., 2015). Serving as catalysts for collaboration between government and industry (SDSN, 2020), sustainable universities are characterized by four dimensions: Education, Research, Community Outreach, and Campus Operations (Alshuwaikhat and Abubakar, 2008).

The evolution from Information and Communication Technologies to Clean Technologies, which emphasize environmentally friendly practices, is notable. HEI are increasingly embracing digital services, eliminating the necessity for physical presence and aligning with the principles of clean technologies to promote sustainability. (Abad-Segura et al., 2020)

In the realm of education, the integration of Digital Transformation represents a dynamic process that necessitates an evolution in teaching methodologies. This transformation aims to enhance the overall educational experience, fostering efficiency and facilitating collaboration (Verhoef and Du Toit, 2018). HEI are adopting hybrid approaches, blending traditional and virtual spaces, thereby bridging online and offline learning modalities. This shift is indicative of a broader trend, including contemporary educational methods such as Do It Yourself education (Abad-Segura et al., 2020).

Beyond the considerations of physical sustainability, another facet of Sustainable Education can be delineated with respect to enduring equitable education and the promotion of Lifelong Learning.

This second aspect is also included within SDG Number 4, as the Key elements of the SDG Number 4 are Lifelong Learning Journey and "by 2030 Ensure equal access for all men and women to quality technical, professional and superior training, including university education" (United Nations, 2015). Integrating Digital learning within the institute facilitates the above goals as well as it also contributes to improved student academic performance and disabling the need of the physical classes (Benta et al., 2015).

### 2.2 Self-Sovereign Identity

SSI epitomizes a paradigm shift in digital identity management, endowing individuals with the autonomy to selectively share information. This not only imparts a heightened level of security but also stands in stark contrast to traditional, centralized identity providers. The decentralized nature of SSI ensures

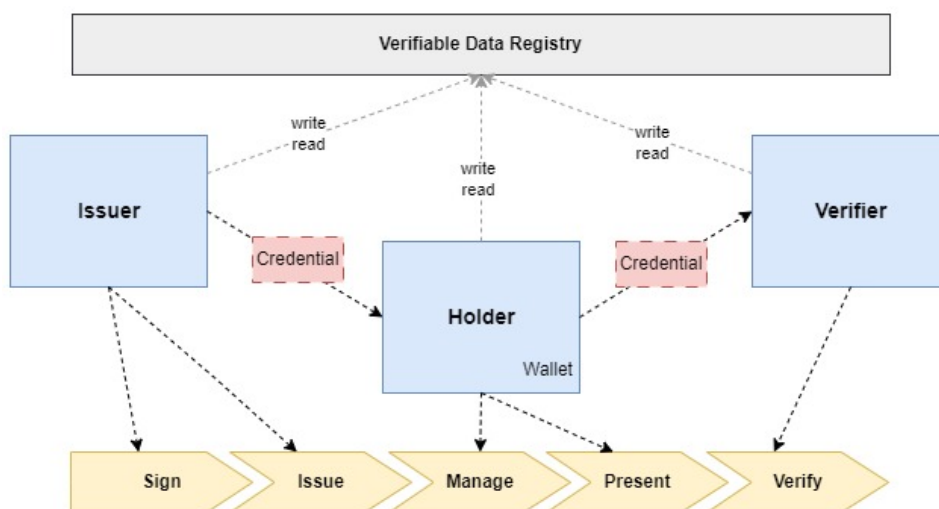


Figure 1: Entities of SSI and trust triangle, taken from (Walt.id, 2024).

individuals maintain control over their personal data, thereby mitigating the risks inherent in centralized databases. This enhanced security, coupled with the individual’s authority to determine the extent of information disclosure, positions SSI as a robust solution for digital identity management. Its implications for privacy and security resonate significantly in our increasingly interconnected world. (Tobin and Reed, 2016)

SSI comprises of three integral components as shown in Figure 1:

- **Holder.** Someone who can receive, manage and share their digital Verifiable
- **Issuer.** Party with the authority to issue the digital Verifiable Credentials (VC)
- **Verifier.** Party verifying the digital VC

This tripartite structure not only streamlines identity processes but also reinforces the security and privacy foundations upon which SSI is built.

### 2.3 Self-Sovereign Identity in Higher Education Institutions

A variety of stakeholders are actively working towards integrating SSI wallets within the educational sector, notably in HEI. These efforts largely emphasize the efficiency gains brought forth by the digitization of processes. To realize this goal, the encryption of data and the establishment of trust are essential components inherent to the SSI framework (van Dijk and Rikken, 2023).

However, it remains unclear what potential exists, or could be achieved, for equitable and Lifelong

Learning through the use of SSI Wallets in the educational context. These aspects are incorporated into the use case of the NBP presented in subsequent section.

## 3 BIRD WALLET

The BIRD project (DAAD, 2024), a prototype initiative under the NBP, has embraced the evolving concept of SSI wallet to facilitate digitalization. The rationale behind incorporating the SSI wallet in this project is to establish a robust and sustainable digital infrastructure specifically tailored for federated learning environments. To comprehensively explore the implications of this integration, it is imperative to delve into the design of the wallet, its seamless integration with the learning environment, and the various use cases that contribute to fostering a sustainable future.

### 3.1 Wallet Design

The interoperable BIRD Wallet as depicted in Figure 2, a customized Enmeshed app, maintains a consistent operational principle, as depicted in the layered architecture of the Enmeshed app illustrated in Figure 3. This wallet incorporates SSI principles, empowering users with control over their data while improving security through a zero-knowledge backbone architecture — without the use of decentralized ledger technologies such as blockchains. Notably, the backbone employs state-of-the-art encryption to store data, ensuring that even the backbone administrator cannot access users’ personal data.

The Enmeshed architecture comprises of follow-

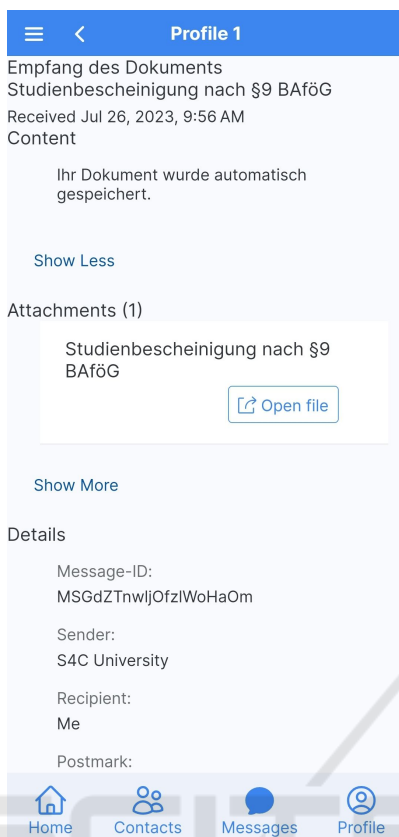


Figure 2: BIRD Wallet.

ing three main components (Enmeshed, 2024):

- **App**

The end-user software client provides an application for utilizing wallet functionalities. Users can securely store and share messages and documents through the free to download wallet app. This component serves as the interface for interacting with the wallet, facilitating user engagement and data management.

- **Backbone**

Functioning as a centralized encrypted storage and communication component, the backbone plays a pivotal role in facilitating message routing with zero-knowledge. This component serves as the cornerstone for communication between various elements of the system and functions as a data-access, backup, and synchronization helper for user identities. Notably, the backbone ensures robust security measures, preventing even the backbone administrator from accessing sensitive personal data.

- **Connector**

Designed as a software client for organizations, the connector is intended to be hosted on-site for

seamless integration of business logics. It features a REST API that integrates all wallet functionalities, and it is responsible for encryption and decryption on the fly. The connector acts as a bridge between the wallet and organizational systems, facilitating secure communication and data exchange.

The layered diagram and components of the Enmeshed app provide a comprehensive and high-level overview of the design of the BIRD Wallet. This design not only emphasizes user-centric features, such as secure messaging and document sharing but also underscores the importance of robust security measures, particularly in the context of zero-knowledge architecture. The BIRD Wallet, with its tailored implementation within the Enmeshed framework, aims to strike a balance between user empowerment and data security, offering a promising solution in the landscape of digital wallets and identity management systems.

### 3.2 Use Cases for Sustainable Future

The preceding research outlines four conceivable scenarios for a German National Education Platform currently undergoing prototyping in the BIRD Lab: classical learning environments, simulation games, extracurricular certifications, and the digitization of administrative processes (Staegemann. et al., 2022). These scenarios are centered around HEI, where the BIRD Wallet reveals several potential use cases:

- **Administrator**

Receive digital documents or identity data, Receive course fees, Send notifications, Send digital VC, Sendreceive queries

- **Applicant**

Submit digital documents or identity data for course applications, Pay course fees, Receive notifications or digital VC from the institute, Store and manage digital VC, Sendreceive queries

- **Student**

Submit digital assignments, tests, or exams, Receive notifications from teachers, departments, or the institute, Receive digital VC from the institute, Store and manage digital VC, Secure access to digital educational services, Send/receive queries

- **Lecturer**

Send lecture material or announcements to students, Secure access to digital educational services, Send/receive queries

Furthermore, the BIRD platform fosters a federated learning environment where users can search

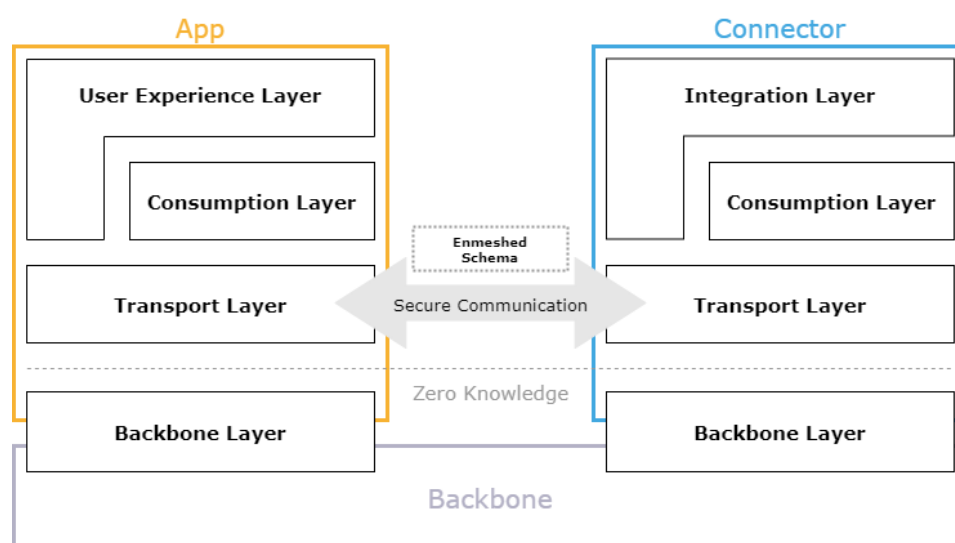


Figure 3: Wallet's layer architecture, taken from (Enmeshed, 2024).

self-assessment tests, preparatory courses, language courses, vocational courses, and degree programs using the "Learning Path Finder" tool borrowed from Digitaler Campus (Bock and Jelinski, 2023). Adhering to Privacy by Design principles, the platform ensures that user search data is neither stored nor retrieved from cookies. Users can also schedule tasks through the "Task Scheduler" tool on the BIRD platform, leading to additional use cases for BIRD platform users leveraging the BIRD Wallet:

- Sharing digital VC to facilitate trusted user searches
- Sharing attributes to filter search results
- Receiving notifications of scheduled tasks
- Secure access to the platform

This delineation underscores the several ways in which the BIRD Wallet can be integrated into digital learning infrastructures, envisioning a sustainable future for education. The seamless alignment of the BIRD Wallet with diverse user roles and functionalities within the educational ecosystem contributes to its potential as a robust and versatile tool for enhancing the overall learning experience.

### 3.3 Integration to Federated Learning Environment

To actualize the aforementioned use cases, the integration of the BIRD Wallet with both the BIRD platform and university systems is imperative. The use cases on the BIRD platform, with the exception of secure access, have already been implemented by seamlessly integrating the BIRD Wallet into the platform,

as illustrated in the system architecture depicted in Figure 4. Adhering to the principles outlined by Enmeshed, the BIRD platform extends features to wallet users by hosting the wallet connector. The communication between the hosted connector and wallet takes place through the secure backbone, which also facilitates storage and management functionalities.

The integration with university systems is a critical step towards the realization of all presented potential use cases. The blueprint for this implementation is elucidated in the system architecture diagram in Figure 5. Existing university systems include the Identity and Access Manager, Campus Management System, and Learning systems. Parallel to the integration with the BIRD platform, a prototypical integration of the wallet with a Campus Management System has already been accomplished to enable the sharing of documents bidirectionally. As part of the BIRD project, a signature service named Signier Service has been prototyped. Given the criticality of ensuring trust in digital credentials, the integration of Signier Service is currently in progress. Simultaneously, efforts are underway to integrate the wallet with learning systems.

In addition to these integrations, an ongoing preliminary study is examining the feasibility of leveraging SSI principles for identity management. This study aims to explore the potential utilization of the BIRD Wallet in providing secure access in a more user-centric manner. The exploration of SSI as an Identity Manager aligns with the broader goals of the BIRD project, emphasizing a user-centric approach to secure access and identity management.

In summary, the integration efforts encompass both the BIRD platform and university systems, paving the way for a comprehensive implementation



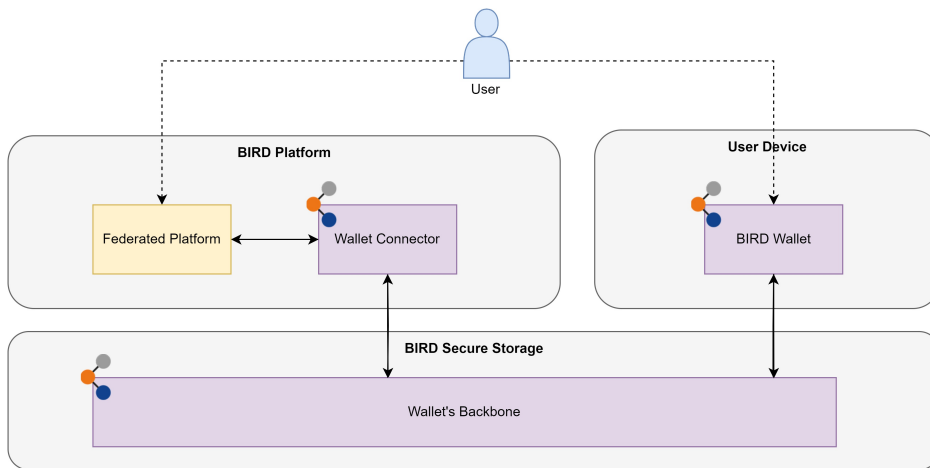


Figure 4: System architecture: BIRD Wallet integration with BIRD platform.

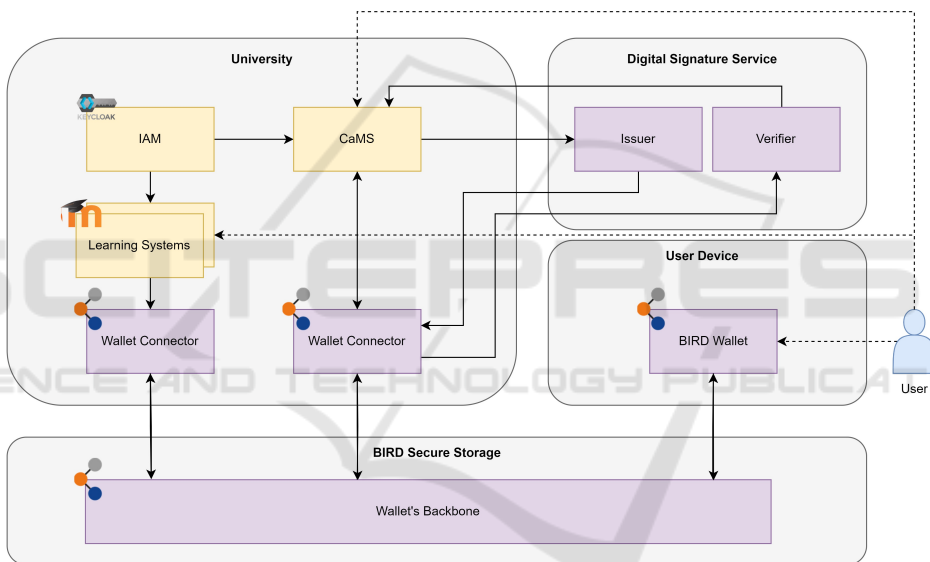


Figure 5: System architecture: BIRD Wallet integration with University systems.

of the BIRD Wallet across diverse use cases. This integration not only enhances the functionalities available to users but also contributes to the realization of a secure, user-centric, and versatile digital learning ecosystem.

#### 4 DISCUSSION & OUTLOOK

Various parties such as government, academic actors and businesses are paying close attention to the development of the SSI wallets in context of HEI. As SSI technology offers numerous benefits and advantages, it becomes lucrative also for the educational institutions to integrate the SSI wallets in their system

landscapes. The related work demonstrates the potential use cases of SSI wallets getting unveiled in educational settings to increase security and streamline processes. Using the potential of this secure and user-centric technology could lead to not only simplifying the user experience but also positively impacting the sustainability aspect within the federated learning environment.

This paper contributes to the discourse by proposing several application scenarios and use cases, as well as suggests system architectures for integrating the SSI wallet. In addition to streamlining process and increasing security, this approach also exhibits how SSI wallets can enable digital educational infrastructures to support Lifelong Learning. It is also conceiv-

able that the integration of SSI wallets into the system architectures of HEI could lead to an increased number of digital teaching offerings. Concomitantly, the simplification of administrative processes at HEI may allow access to courses and content for individuals who, due to their socio-economic situation, would otherwise be excluded in a present environment. Thus, the deployment of this technology can also support equal education and thereby contribute to the achievement of other sub-goal(s) of SDG Number 4. However, as it is a proposition paper and implementation is currently in the prototypical state. The authors have not yet provided any empirical evidence actually improving the sustainability or measuring by how much it was improved compared to the existing system architectures. Further investigations are intended to assess how the integration of SSI wallets into the federated learning system affects the behavior of stakeholders in education, particularly students. Consequently, assessing the impact on the sustainable future of HEI is a multifaceted task that requires a comprehensive understanding of the intricacies involved in the integration of SSI wallets.

As (Katini et al., 2023) highlights in their work, the role of mobile wallets in not only reducing CO<sub>2</sub> emissions. Inspired by their methodology in measuring outcomes, for future work we contemplate conducting a survey to gather qualitative feedback on how the SSI wallet is benefiting educational users in context of the aforementioned use cases in HEI.

Currently the BIRD project progresses on the prototypical implementation and there will be an open beta testing phase for the NBP, more steps can be taken towards measuring the actual impact on sustainability.

## 5 CONCLUSION

Governments and societies need to equip their citizens with necessary competencies, knowledge and values crucial for creating a sustainable future together (UNESCO, 2024). One of the five main focus areas of UNESCO's Education for Sustainable Development is transforming learning environments in order to promote sustainability. That is precisely what the BIRD Lab is trying to achieve: providing new application scenarios for federated learning environments through innovation and prototypically implementing those.

The publication at hand outlines the BIRD Lab's proposal on unveiling the whole potential of what SSI Wallets offer and how their usage can promote the sustainability within federated learning environments.

Hereby, the contribution is twofold, on the one hand, it helps enhancing the digital infrastructure for a sustainable university and, on the other hand, possible use cases for interoperability are provided. Moreover, this paper presents how SSI Wallets can be integrated within BIRD platform and University system landscapes in general, thus, providing the foundation for further research.

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