SCHOOL OF SCIENCE AND TECHNOLOGY EDUCATION
FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGERIA

11th HYBRID INTERNATIONAL CONFERENCE

THEME:

STEAM EDUCATION AND ARTIFICIAL INTELIGENCE (AI): BUILDING A SKILLED AND INNOVATIVE WORKFORCE

CONFERENCE PROCEEDINGS

MONDAY 6TH TO FRIDAY 10TH OCTOBER, 2025

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

11th

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ACKNOWLEDGEMENTS

Local Organizing Committee of the 11th International Conference of School of Science and Technology Education (SSTE), Federal University of Technology, Minna, appreciates the Management of the University for the Unflinching Support given to the team which led to the success of this Conference. We also wish to express our profound gratitude for the assistance rendered by the University Management especially in disseminating information relating to this Conference using the University website, Campus News, and the University Search FM.

We are grateful to the Dean, School of Science and Technology Education (SSTE) for hosting this Conference despite the economic situation in the country. His encouragement, advice, and moral support gave the Local Organizing Committee the strength to complete this task and make the Conference successful.

We Sincerely thank the academic staff of the School and University Community for the essential roles played towards the success of the Conference. We thank the non-teaching staff for their roles which contributed to the success of this Conference.

Efforts of the Editorial Board are commendable for making sure that the Book of Proceedings is ready for use by the relevant stakeholders. We appreciate the efforts of the Keynote speaker, Lead Paper presenters, and all other participants for attending this Conference both physically and virtually despite their tight schedule.

We also commend the postgraduate students of the school for sparing their time to participate in all the events. Above all, we thank God Almighty for the strength given to the LOC members to discharge their enormous tasks.

PREFACE

The rapid integration of Artificial Intelligence (AI) in various industries has transformed the way we live and work, emphasizing the need for a skilled and innovative workforce. The convergence of Science, Technology, Engineering, Arts, and Mathematics (STEAM) education with AI has become a crucial factor in driving economic growth, innovation, and competitiveness.

This conference proceedings brings together experts, researchers, and practitioners to explore the intersection of STEAM education and AI, focusing on building a workforce equipped to thrive in an AI-driven world. The papers presented here cover a range of topics, including AI-powered learning tools, STEAM curriculum development, and the future of work in the age of AI.

Hence, the theme of this conference is apt and provides opportunities where experts brainstorm so that international communities can benefit from one another and also respond to emerging trends in *STEAM* Education and AI in order to build a skilled and innovative workforce. It is worth noting that, proper synergy of STEAM and AI would have a greater influence on the quality of manpower injected into the labour market which may determine the economic growth of any nation.

The theme and sub-themes of this conference, " **STEAM Education and Artificial Intelligence (AI): Building a skilled and innovative workforce** " are based on the prevailing circumstances in education sectors in developing nations. I am sure this conference has provided an avenue for researchers and educators to share their ideas on the 21st-century skills that can enhance quality education and self-reliance in underdeveloped and developing nations across the world. I hope the theme and sub-themes meet the needs of the stakeholders in education.

The sub-themes are:

- Artificial Intelligence, Teacher Education and Career Development
- Artificial Intelligence and Gender Issues in Education
- Language and Communication in the Era of Artificial Intelligence
- Transforming Library and Information Science Through Artificial Intelligence for Innovative Workforce
- Artificial Intelligence-Driven Entrepreneurship for Innovative Education
- Ethical Implications of Artificial Intelligence in TVET and STEAM Education
- I C T and Generative Artificial Intelligence in STEAM Education
- Agriculture and Artificial Intelligence for Food Security and Economic Sustainability
- Artificial Intelligence and Engineering Education for Skilled Workforce
- Artificial Intelligence-Driven Educational Technology for Innovative Workforce
- Inclusive Education in the Era of Artificial Intelligence
- Artificial Intelligence and Innovative Workforce in National Security

The Local Organizing Committee is thankful to the participants of 2025 conference for their contributions. God bless you all.

Prof. I. Y. Umar
LOC Chairman

WELCOME ADDRESS BY THE VICE-CHANCELLOR, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, PROFESSOR FARUK ADAMU KUTA AT THE OPENING CEREMONY OF THE 11TH INTERNATIONAL CONFERENCE OF THE SCHOOL OF SCIENCE AND TECHNOLOGY EDUCATION, HELD AT SSTE BOARD ROOM, BOSSO CAMPUS, FUT MINNA.
6TH - 10TH October, 2025

Distinguished colleagues, esteemed scholars, invited guests, ladies and gentlemen, it is with great delight and a profound sense of responsibility that, on behalf of the Governing Council, Management, Staff, and Students of the Federal University of Technology, Minna, I warmly welcome you all to the opening ceremony of the 11th International Conference of the School of Science and Technology Education. On behalf of the University community, I extend warm greetings to our participants from within Nigeria and across the globe who have joined us for this intellectually stimulating gathering. Your presence here is a testament to your commitment to advancing knowledge, innovation and collaboration in the critical fields of science, technology and education.

A warm welcome goes to all our distinguished speakers, especially our Keynote Speaker, Professor O. S. Olatunji, Dean, Faculty of Computing, Adekunle Ajasin University, Ondo State**.** We are equally honoured to have with us our Lead Paper Presenters: Professor Aede Hatib Bin Musta'amal, Faculty of Educational Sciences and Technology, University Teknologi Malaysia**,** Professor Jelili Adebayo Jimoh, Head of Department, Vocational and Technology Education, University of Lagos, Akoka, Lagos State, and, Professor Binyao Zheng, Bagwell College of Education, Kennesaw State University in the USA. We thank you sincerely for honouring our invitation and for bringing your wealth of expertise to enrich this conference.

The theme of this year's conference, ***"STEAM Education and Artificial Intelligence (AI): Building a Skilled and Innovative Workforce,"*** could not be more timely or relevant. In today's rapidly evolving global landscape, education must transcend traditional boundaries to equip learners with the competencies required for the 21st century. Science, Technology, Engineering, Arts and Mathematics (STEAM) provide a holistic framework that integrates creativity with technical expertise. Coupled with the transformative power of Artificial Intelligence, this framework promises to shape not only the future of education, but also the future of industry, governance, and everyday life.

Artificial Intelligence is no longer a distant prospect; it is already reshaping the way we work, learn and interact. From healthcare to agriculture, from business to the creative industries, AI is creating opportunities that demand new skills and fresh ways of thinking. For Nigeria and indeed Africa, the challenge before us is how to harness these opportunities to address our local needs, reduce inequalities and empower our youths with the skills necessary to thrive in an increasingly competitive world. This is why the discourse we begin today is of immense importance.

As a university of technology, FUT Minna remains committed to driving innovation, research, and entrepreneurship. We recognize that higher education institutions have a pivotal role in preparing a workforce that is not only technically competent but also adaptable, creative and ethically responsible. By embracing STEAM education and integrating Artificial Intelligence into our teaching and research, we are laying the foundation for a new generation of problem-solvers and innovators who can propel Nigeria and Africa into a future of sustainable growth and development.

I must commend the School of Science and Technology Education for its consistency in organizing this international conference, now in its 11th edition. Over the years, this conference has provided a platform for robust dialogue, collaboration and knowledge sharing among educators, researchers, and industry practitioners. This year's theme, in particular, challenges us to rethink our curricula, pedagogies and policies to align with global trends while remaining responsive to local realities.

Permit me to also acknowledge the efforts of the organizing committee whose dedication has ensured the success of this event. To our guests, I invite you to enjoy not only the academic engagements but also the warmth and hospitality of Minna and Niger State.

Once again, I warmly welcome you all to the 11th International Conference of the School of Science and Technology Education. May the deliberations here mark a turning point in our collective pursuit of excellence in education, innovation and nation-building. I wish you all a productive conference, an enjoyable stay in Minna and safe travels back to your various destinations when the event comes to a close.

Thank you and God bless you all.

WELCOME ADDRESS BY THE DEAN, PROFESSOR ROBERT O. OKWORI, SCHOOL OF SCIENCE AND TECHNOLOGY EDUCATION, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE, NIGERIA AT THE OPENING CEREMONY OF THE 11TH INTERNATIONAL CONFERENCE OF THE SCHOOL ON 8TH OCTOBER, 2025.

The Vice-Chancellor Federal University of Technology, Minna
Deputy Vice-Chancellors (Academics and Administration)
Registrar
Bursar
Librarian
Keynote Speaker
Lead Paper Presenters
Deans, Heads of Departments,
Distinguished scholars,
Ladies and gentlemen

It is with great delight and a deep sense of responsibility that I, on behalf of the School of Science and Technology Education, Federal University of Technology, Minna, warmly welcome you all to the 11th International Conference of our School. This gathering continues our tradition of fostering academic excellence, advancing frontiers of knowledge, and providing platforms for dialogue on issues that shape the future of education and development, both within Nigeria and globally.

This year's theme, ***"STEAM Education and Artificial Intelligence (AI): Building a Skilled and Innovative Workforce"*** is timely and highly significant. Across the world, nations are aligning education with the demands of a rapidly changing technological landscape. For Nigeria, the integration of Science, Technology, Engineering, Arts, and Mathematics (STEAM) with the transformative power of Artificial Intelligence offers both immense opportunities and urgent responsibilities. AI is not only revolutionizing how we live and work but is also redefining the very fabric of education, how we teach, how students learn, and how knowledge is applied to solve societal challenges.

For our nation, this means preparing a workforce that is not only technically proficient but also innovative, adaptive, and creative. It calls for an education system that emphasizes problem-solving, critical thinking, and collaboration, thereby equipping Nigerian youths to compete in the global knowledge economy. More importantly, it calls for harnessing AI and STEAM education to address local challenges whether in healthcare, agriculture, energy, or national security while building sustainable pathways for development.

We are indeed privileged to have with us distinguished scholars and experts whose work embodies the spirit of this conference. Our Keynote Speaker, Prof. O. S. Olatunji, Dean of the Faculty of Computing, Adekunle Ajasin University, is a resourceful and innovative computer professional, researcher, and teacher. His expertise in Artificial Intelligence, Computational Intelligence, and Machine Learning applied across fields such as Oil and Gas, intrusion detection, biomedical prediction, and bioinformatics will no doubt provide us with invaluable insights into the revolutionary impact of AI on skills formation and professional growth. We are equally honored to welcome Prof. Jelili Adebayo Jimoh, Head of the Department of Vocational and Technology Education at the University of Lagos, whose contributions to vocational and technical education remain significant to Nigeria's quest for skills-based development.

From beyond our borders, we are delighted to host Prof. Aede Hatib Bin Musta'amal of Universiti Teknologi Malaysia, whose scholarship in technical and engineering education, particularly in creativity, innovation, and competency profiling in TVET, continues to shape global conversations on workforce readiness.

We are also privileged to have Prof. Binyao Zheng of Kennesaw State University, USA, a distinguished scholar in educational leadership, program evaluation and global citizenship education. His research on educational policy and student success brings a much-needed international perspective on how education systems can foster inclusivity and excellence.

At this juncture, I must sincerely acknowledge and commend the tireless efforts of the Chairperson and members of the Local Organizing Committee. Your dedication, meticulous planning, and unwavering commitment have made this 11th International Conference of the School of Science and Technology Education a reality. From the early stages of preparation to the seamless execution we are witnessing today, your teamwork and sacrifice have ensured that this gathering will be both intellectually rewarding and memorable. On behalf of the School, I say a heartfelt thank you.

Distinguished colleagues and guests, this conference is not only an academic exercise but also a call to action. As we deliberate, let us think critically about how we can adapt STEAM education and AI to meet Nigeria's developmental aspirations. Let us explore how academia, industry and government can collaborate to produce a skilled and innovative workforce that will drive sustainable growth.

On this note, I once again welcome you to the 11th International Conference of the School of Science and Technology Education. May our engagements here be intellectually stimulating, practically impactful, and historically significant.

Thank you, and welcome.

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PRIVACY-CENTRIC SELF-SOVEREIGN IDENTITY FRAMEWORK DESIGN FOR PUBLIC BLOCKCHAINS

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Abstract
Identity management has evolved over time, yet centralized and federated models remain vulnerable to large-scale data breaches and privacy concern. This paper presented a privacy-centric Self-Sovereign Identity (SSI) framework for public blockchains that incorporates advanced cryptographic method, such as ephemeral Decentralized Identifiers (DIDs), BBS+ selective disclosure signatures, and accumulator-based revocation. The framework was designed and evaluated using a Design Science Research (DSR) methodology, it encompassing architectural design, prototype implementation, and performance testing on the Ethereum testnet. With a slight performance overhead of 10–15% in latency and throughput, experimental results show an 80% reduction in linkability risk when compared to baseline SSI models. These results demonstrate that blockchain-based identity systems can successfully balance privacy, scalability, and usability. The study contributes a deployable, empirically validated architecture that advances privacy-by-design principles for next-generation digital identity infrastructures.

Keywords: *Self-Sovereign Identity (SSI), Blockchain, Privacy, Verifiable Credentials, Decentralized Identifiers*

Introduction
Identity management has undergone a transformation from physical documents to centralized and federated digital systems (Buchler, 2023). while federated identity solutions, such as Google or Facebook logins, provide convenience, they also concentrate sensitive personal data in centralized repositories, making them prime targets for cyber attacks. The severity of this threat is exemplified by the 2017 Equifax intrusion, which compromised the personal information of 147 million individuals (Berghel, 2017). Such flaws erode user confidence and endanger personal privacy, business integrity, and national security (Bhattacharya *et al.,* 2020).

Self-Sovereign Identity (SSI) is a paradigm that allows individuals to take ownership of their digital identities from third-party providers (Mühle et al., 2018). By employing blockchain technology, SSI allows users to manage and deliver verifiable credentials without the need for middlemen (Bandara *et al.*, 2021). However, the transparency of public blockchains poses new privacy problems, as transaction patterns can be studied to identify users (Pava-Díaz *et al.*, 2024). Existing SSI solutions frequently struggle to balance verifiability and privacy, leaving a significant research vacuum (Shuaib *et al.*, 2022).

This paper proposes and evaluates a privacy-centric SSI framework that incorporates advanced cryptographic techniques to address the identified challenges. The primary objective is to design a system that provides users with data sovereignty while satisfying the performance requirements of contemporary digital economies. The specific objectives are to design a multi-layered, privacy-

by-design SSI framework, implement a prototype, and evaluate its performance and privacy guarantees relative to a baseline model.

Related Work

Traditional, federated, and decentralized systems are the three primary phases of identity management's development. Conventional systems used tangible, falsifiable documents. Federated identity, which was introduced by the internet era and allows services like Google and Facebook to authenticate users across platforms, has led to centralized points of failure and serious privacy issues (Aldosary & Alqahtani, 2021).

Decentralised identity, powered by blockchain, emerged to eliminate central authorities, enhancing security and user autonomy (Loffi *et al*., 2025). SSI represents the maturation of this trend, giving individuals full ownership of their digital identities through three core components (Mulaji & Roodt, 2022):

Decentralised Identifiers (DIDs): User-controlled, globally unique identifiers that are not dependent on a central registry, as specified by the W3C (2022).

Verifiable Credentials (VCs): Tamper-evident, digitally signed claims issued by a trusted entity that a user can present to a verifier without the issuer's direct involvement (W3C, 2025).
Digital Wallets: Secure software applications where users store their DIDs and VCs, manage cryptographic keys, and control the selective disclosure of their information (Mulaji & Roodt, 2022).

Blockchain offers SSI a trust anchor, but because it is public, there are privacy concerns (Nokhbeh *et al.*, 2021). Adversaries may be able to correlate user activity by posting DIDs or credential proofs on-chain (Samovar & Samovar, 2025). Privacy-Enhancing Technologies (PETs) are essential to reducing this. A user can prove a claim using Zero-Knowledge Proofs (ZKPs) without disclosing the supporting information (Schardong & Custódio, 2022). More sophisticated signature schemes, such as BBS+, are made especially for SSI and allow a holder to generate unlinkable proofs that reveal only a portion of a credential's attributes (Tessaro & Zhu, 2023).

Current SSI systems, such as Microsoft ION (Dingle, 2020), uPort (Panait et al., 2020), and Sovrin (Kassem et al., 2019), have made important contributions, but they have drawbacks because of their scalability, centralization, or insufficient privacy protections. A dearth of empirically validated frameworks that integrate multiple PETs and assess their practical performance on public blockchains is evident in the numerous studies that have suggested theoretical privacy enhancements (Čučko & Turkanović, 2021). By creating and evaluating a comprehensive SSI framework on Ethereum, this study fills that gap.

Methodology

The suggested privacy-centric SSI framework is the technical artifact of the Design Science Research (DSR) approach, which is centered on its development and assessment. Problem identification, framework design, prototype implementation, and thorough evaluation were all done iteratively in this methodology. A tiered architecture is used in the design of the suggested

framework to guarantee adaptability and modularity. As seen in Figure 1, it is composed of four separate layers.

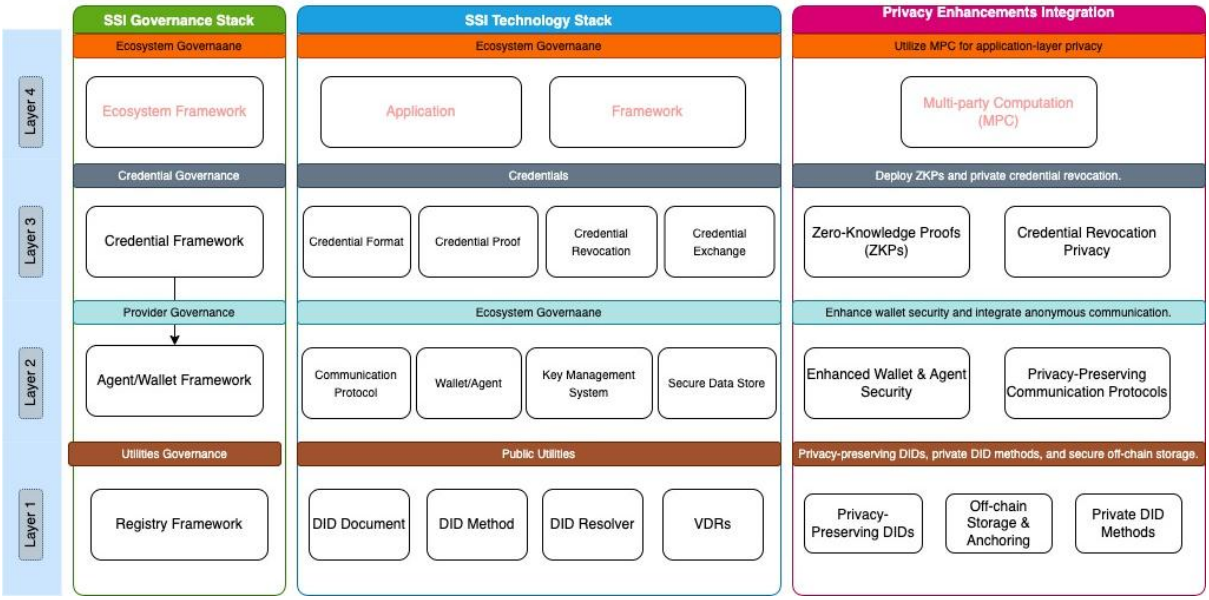

Figure 1: The Four-Layer SSI Framework Architecture

i. **Utilities Layer:** Utilities Layer: The fundamental cryptographic primitives are provided by this layer. In order to avoid long-term tracking and correlation, it introduces ephemeral DIDs, which are transient identifiers created for individual interaction sessions. To reduce data exposure, only a hash commitment is anchored rather than the entire DID being placed on-chain.

ii. **Provider Layer:** This layer enables private and secure communication between identity actors (issuers, holders, and verifiers). By using the DIDComm v2 protocol and onion routing techniques, it obscures metadata, making it impossible for traffic analysis to link communicating parties.

iii. **Credential Layer:** The entire lifecycle of verifiable credentials is managed by this layer. Strong selective disclosure is made possible by the use of BBS+ signatures when issuing credentials. A user can use a credential to show certain attributes, like their employment status, without revealing other personal information, such as their employee ID number or start date. By using cryptographic accumulators for revocation, the framework allows a user to prove that their credential has not been revoked without revealing the credential's identity on a public list.

iv. **Ecosystem Governance Layer:** This uppermost layer makes sure the framework complies with legal and regulatory mandates, including eIDAS 2.0 and GDPR. Using smart contracts to transparently enforce policies, it establishes the guidelines for auditability, consent, and trust within the ecosystem.

Solidity was used for smart contracts and Node.js for wallet applications in the implementation of a prototype of this framework on the Ethereum Goerli testnet. The Hyperledger Ursa library handled cryptographic operations. Performance, privacy, and scalability were assessed using a combination of network analysis tools (Wireshark), load testing software (JMeter, Locust), and blockchain monitoring tools (Etherscan).

Results and Discussion

The framework was evaluated against a baseline SSI model that uses static DIDs and does not include advanced PETs. The evaluation focused on system performance, privacy guarantees, and scalability.

System Performance

Under increasing concurrent request loads, throughput (verifications per second) and latency (end-to-end verification time) were measured. The suggested framework added a slight latency overhead of roughly 14–25% over the baseline, as indicated in Table 1. The computational expense of checking revocation accumulators and producing selective disclosure proofs is the reason for this.

Table 1: Latency Comparison between Baseline and Proposed SSI Framework

Concurrent Requests	Baseline SSI (ms)	Proposed Framework (ms)	Overhead (%)
10	120	145	+20.8%
50	248	310	+25.0%
100	325	392	+20.6%
300	540	620	+14.8%
500	730	835	+14.4%

The framework's peak throughput was about 11–14% lower than the baseline, with 115 transactions per second compared to 130 transactions per second. Despite this performance trade-off, the overhead stays constant and does not increase under increased loads, demonstrating the architecture's durability. The performance remains within reasonable bounds for real-world applications where enhanced privacy is an essential requirement.

Privacy and Scalability

The primary goal was enhance privacy. By mimicking an adversary's attempt to connect a user's interactions across sessions, the risk of privacy leakage was assessed. The findings were unmistakable: the adversary's linkability success rate was lowered by 80% from 61% in the baseline model to just 12% in the suggested framework by combining randomized BBS+ proofs, onion routing, and ephemeral DIDs. The selective disclosure mechanism was also quite successful on average, individuals were only able to disclose 6–22% of the required features of their credentials, as opposed to 100% in the baseline.

Scalability tests of the framework's scalability revealed that its performance increases linearly with the number of validator nodes and gradually declines when the number of concurrent users rises into the thousands. It is confirmed that the privacy improvements do not result in a scaling bottleneck because the performance overhead relative to the baseline stayed constant at about 10-15%.

Conclusion and Recommendations

This research successfully designed, implemented, and evaluated a privacy-centric SSI framework on a public blockchain. The study concludes that the integration of ephemeral DIDs, BBS+ selective disclosure, and cryptographic accumulators provides a robust solution to the privacy challenges inherent in blockchain-based identity systems. The experimental evidence validates that this approach substantially reduces the risk of user activity correlation and minimizes data exposure, achieving these gains with an acceptable and stable performance trade-off. The framework proved to be both scalable and secure, making it a viable solution for real-world deployment in sensitive domains such as national security and enterprise environments.

Based on these findings, the following recommendations are made:

1. **For Developers:** Prioritize the adoption of standards-compliant PETs like BBS+ signatures and accumulator-based revocation to enforce privacy-by-design principles in digital identity systems.
2. **For Organizations:** Invest in scalable verifier infrastructure and establish clear governance frameworks for key management and credential lifecycle policies to ensure trust and regulatory compliance.
3. **For Future Research:** Explore the integration of post-quantum cryptography to ensure long-term security and investigate layer-2 scaling solutions to further reduce on-chain costs and latency.

This study contributes an empirically validated architecture that advances the field of digital identity by demonstrating that privacy, security, and scalability can be effectively balanced. It provides a technical foundation for building a more trusted, user-centric, and secure digital workforce for the future.

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