Ulysseus
EUROPEAN UNIVERSITY

Navigating Pathways: Digital Transformation of Industry – Ulysseus R&I Conference 2025

CONFERENCE PROCEEDINGS

October 20th, 2025. Košice

Technical University of Košice

CONFERENCE PROCEEDINGS

Publisher: Technical University of Košice
Letná 1/9, 042 00 Košice-Sever, Slovakia

Publishing date: October 20th, 2025

Print type: softcover

Language: english

Pages: 33

Editor: Lucia Knapčíková

ISBN: 978-80-553-2785-3

Navigating Pathways: Digital Transformation of Industry

Ulysseus R&I Conference 2025

The conference is a result of the implementation of the Ulysseus – European University Alliance project.

The conference is a part of the Ulysseus Košice Week.

Contents

Ulysseus R&I Conference 2025
Navigating Pathways:Digital Transformation of Industry
20 October 2025, Košice, Slovak Republic

Copernicus satellite images and Python for Aviation

Peter Szabó
Department of Aviation Technical Training
Faculty of Aeronautics
Technical University of Košice
Košice, Slovakia
peter.szabo@tuke.sk

Tibor Muszka
Department of Aviation Technical Training
Faculty of Aeronautics
Technical University of Košice
Košice, Slovakia
tibor.muszk@tuke.sk

***Abstract*—We present a modular system that utilises open-access Copernicus satellite data and Python automation to monitor civil infrastructure and the surrounding areas of airports. Our pilot project focuses on R2 expressway construction and the Košice Airport Area of Interest. By filtering images with <10% cloud cover and using GeoJSON polygons, we ensure precise, comparable observations.**

Keywords—Copernicus satellite data, Python automation, airport surroundings, GeoJSON polygons, remote sensing, change detection, open-access Earth observation

I. Introduction

Monitoring airport surroundings and infrastructure is essential for ensuring aviation safety and environmental compliance. The increasing number of satellites orbiting the Earth offers new opportunities to observe changes in land use, vegetation, and construction activities with high frequency and detail. By integrating data from Sentinel-1 (radar) and Sentinel-2 (optical) satellites, it is possible to track changes in the Terminal Control Area (TMA), extending up to 45 km around airports. Python-based methods support automated image analysis and change detection, enabling early identification of risks such as unauthorised construction or environmental degradation. Easily accessible platforms, such as the Copernicus Open Access Hub or OpenEO, enhance availability and usability for both research and operational purposes. A current example is the observation of the R2 ring road construction near Košice, which may influence the surrounding environment and operations at Košice International Airport. Further improvements in image processing, real-time analysis, and data fusion are needed to advance automation and support regulatory compliance in the aviation sector.

II. Monitoring Examples

The Copernicus programme [1] provides access to a vast archive of satellite data, with nearly 95 petabytes of Earth observation information currently available. In this study, we used data from two satellites of the Sentinel constellation: Sentinel-1 and 2. A brief comparison of these satellites is provided in the table below. A more detailed discussion of Sentinel-1 and Sentinel-2, and their use in aviation safety monitoring, can be found in our previous article [2]. Sentinel-1 is particularly useful for monitoring changes regardless of weather or lighting conditions, while Sentinel-2 offers high-resolution optical imagery ideal for vegetation and land cover analysis. This combination allows for robust change detection in both natural and built environments, supporting infrastructure surveillance around airports.

Feature	Sentinel-1	Sentinel-2
Sensor Type	Radar (SAR)	Optical (MSI)
Image Type	Active (sends signals)	Passive (captures sunlight)
Weather Use	Works in all weather	Needs clear skies
Resolution	10–20 m	10 m
Revisit Time	3–5 days	Up to 5 days
Aviation Use	Sees through fog, tracks elevation	Tracks land use, vegetation
Strength	Reliable in any weather	Sharp, colourful images
Weakness	Less visual detail	Can't see through clouds or at night

Figure 1 Sentinel-1 vs. Sentinel-2, Simple Comparison

A. R2 Expressway Monitoring

A time-lapse series of satellite images tracks the progress of R2 expressway construction near Košice. Sentinel-2 data is filtered by cloud cover and collected biannually, allowing for the creation of a visual .GIF animation that illustrates the pace and extent of development over time. This method enables remote documentation of construction stages and environmental impact along transport corridors.

B. Airport Area Monitoring

A prototype monitoring system has been created to define observation zones around airports using GeoJSON polygons, in line with ICAO safety standards. These spatial boundaries enable consistent tracking of changes in terrain, infrastructure, and vegetation. Over time, this system can support automated alerts for changes, enhance hazard detection, and contribute to safer airspace and ground operations, particularly in obstacle clearance zones and runway approach areas.

C. *Infrastructure Distance Calculation*

Using satellite-based coordinates and Python's geopy geodesic method, the system measures the length of road segments and infrastructure elements. This technique confirms that remote sensing data can be accurately used for digital infrastructure mapping and validation. This method supports applications in civil engineering, urban planning, and safety assurance—particularly where field data collection is limited or costly.

III. WORKING WITH SATELLITE IMAGES

Working with satellite imagery is a fundamental aspect of the Fourth Industrial Revolution. Earth observation data enables quicker and more precise decision-making in areas such as civil aviation, urban development, and infrastructure monitoring. A detailed description of these satellites, and the first steps can be found in our previous article [3].

A. *Interactive and GUI-Based Platforms*

For users seeking quick access to visual insights, web-based platforms like Sentinel Hub EO Browser facilitate manual exploration and analysis of satellite data. These tools provide cloud filtering, NDVI and other index visualisations, time-series animations, and basic classification options, often with no programming needed. They are suitable for prototyping, education, or rapid assessments, especially when monitoring vegetation or infrastructure development around airports.

B. *Automated Python Workflows*

For scalable, repeatable, and customisable workflows, Python scripting provides powerful tools to automate the entire pipeline—from data acquisition to analysis and visualisation [4]. Libraries such as:

- sentinelsat (for querying and downloading),
- rasterio (for spatial data handling),
- numpy (for image processing), and
- matplotlib (for output visualisation)

Facilitate efficient handling of large datasets and integration into monitoring systems. Automated pipelines can operate daily or weekly, support change detection, trigger alerts, and export results to databases or dashboards.

C. *Role in Industrial Digital Transformation*

Satellite imagery is becoming increasingly integrated into industrial digital transformation, particularly in sectors that require geospatial awareness. In aviation, this includes:

- Environmental compliance and noise corridor monitoring
- Infrastructure integrity validation without field visits
- Obstacle detection near runways using elevation data
- Dynamic analysis of terrain and land use changes

By integrating remote sensing with automation, organisations lower operational costs, speed up inspections, and maintain compliance with ICAO and local regulations. This not only improves aviation safety but also supports broader smart infrastructure and sustainability objectives.

IV. DISCUSSION

The primary limitation of this monitoring approach is the spatial resolution of satellite imagery, which may not capture fine-scale details, such as small structures or subtle terrain changes. However, this drawback is offset by the high temporal frequency and broad spatial coverage offered by satellites like Sentinel-1 and Sentinel-2. These systems deliver frequent updates and large-scale visibility, making them ideal for regional monitoring over extended periods. The performance and accuracy of change detection largely depend on the quality of preprocessing steps, especially the filtering parameters used to handle cloud cover, shadow effects, and noise. Careful parameter selection is crucial for reducing false positives and improving the reliability of detected changes.

V. CONCLUSION

The platform shows strong potential for automated, scalable monitoring across the civil aviation sector, especially in supporting airport infrastructure management, obstacle detection, and environmental compliance. Its modular design enables integration with existing geospatial workflows and aviation safety protocols. Future work will aim to improve the system with real-time data processing capabilities, allowing near-instantaneous detection of significant changes. Additional development efforts will include data fusion with drone imagery, offering higher spatial detail to complement satellite data and support ground-truth validation. The monitoring framework is also planned to be expanded geographically, covering multiple airports across Europe, especially those with complex terrain or high traffic volume.

REFERENCES

[1] Homepage - Copernicus. [Internet]. .2014. Available from: https://www.copernicus.eu/en/about-copernicus

[2] T. Muszka, P. Szabó,J. Kessler, "Copernicus Satellite Data: Terrain Modelling with Python" in: Proceedings of International Conference on Recent Innovations in Computing. ICRIC 2023. Lecture Notes in Electrical Engineering, vol 1195, Singapore, Springer, https://doi.org/10.1007/978-981-97-3442-9_44

[3] P. Szabó, T. Muszka, "Advanced Satellite-Based Monitoring For Aviation And Infrastructure Development", in: Proceedings of 12th international scientific conference of doctoral students. Košice, Technical University of Košice pp. 39-43 [print]. - ISBN 978-80-553-4833-9

[4] Revillion, C., Mouquet, P., Commins, J., Miranville, J., Wolff, C., Germain, T., Jego, S., Longour, L., Girond, F., Bouche, D., Devillers, R., Pennober, G., Herbreteau, V., "Sen2Chain: An Open-Source Toolbox for Processing Sentinel-2 Satellite Images and Producing Time-Series of Spectral Indices", *arXiv preprint*, Apr 2024.

Ulysseus R&I Conference 2025
Navigating Pathways:Digital Transformation of Industry
20 October 2025, Košice, Slovak Republic

Robot Skills-as-a-Service: Scalable Robot Intelligence

Danil Kozhan
Department of Cybernetics and Artificial Intelligence
Technical University of Kosice
Kosice, Slovak Republic
danil.kozhan@student.tuke.sk

Oleksandr Krokhta
Department of Manufacturing Management
Technical University of Kosice
Kosice, Slovak Republic
oleksandr.krokhta@student.tuke.sk

***Abstract*— Robotic adoption across industries is limited by high costs, rigid functionalities, and the need for extensive developer input to customize tasks. We propose Robot Skills-as-a-Service, a scalable cloud-based marketplace that enables businesses to install, configure, and manage robotic skills without coding. Our solution transforms robots into flexible, reusable systems that can adapt to new tasks through modular skill deployment. The architecture is built on four integrated layers: a cloud layer leveraging Huawei services for scalability and connectivity, a marketplace layer offering both public and private repositories for skill sharing, a no-code UI layer for intuitive robot management, and a robot layer ensuring low-latency execution with onboard computing and 5G connectivity. This approach reduces integration time and costs while enhancing adaptability. Real-world use cases in logistics, healthcare, hospitality, and manufacturing demonstrate how our framework can accelerate digital transformation and unlock new business models for robotic applications.**

Keywords*— Cloud robotics; Scalable robot intelligence; Huawei Cloud; Human–robot collaboration; Digital transformation; Reinforcement Learning

I. Introduction

Robotics has become a cornerstone of digital transformation across industries, yet current systems remain constrained by rigid functionalities, costly customization, and long integration times. Traditional robots are typically preprogrammed for fixed tasks and struggle to adapt flexibly to dynamic environments, limiting their scalability and return on investment. Recent advances in cloud robotics address some of these limitations by offloading computation and storage to the cloud, enabling real-time adaptability, data-driven optimization, and collaborative intelligence among distributed robots [1]. This paradigm shift has demonstrated potential in healthcare and rehabilitation, where cloud-integrated robots support personalization, remote monitoring, and adaptive learning for individuals with disabilities. Building on these developments, our work introduces Robot Skills-as-a-Service: a cloud and marketplace-based framework that allows businesses to install, configure, and share robotic skills without coding. By leveraging modular "skill packages," supported through a layered architecture (cloud, marketplace, UI, and robot execution), we aim to enhance reusability, reduce integration costs, and democratize access to advanced robotic capabilities across logistics, healthcare, hospitality, and manufacturing sectors.

II. System Design

A. Vision and Concept

The concept of Robot Skills-as-a-Service aims to address the rigidity and high integration costs of traditional robotic systems by creating a marketplace for modular, cloud-based robotic skills. Instead of hardcoding capabilities into individual machines, businesses can install and configure skills on demand through a centralized skill store. This approach enables robots to adapt quickly to new tasks, fosters reusability across sectors, and lowers the barrier of entry for organizations with limited technical expertise.

Cloud robotics research already demonstrates the benefits of moving computation and intelligence into scalable infrastructures, such as improved adaptability and collaborative knowledge sharing [1]. Moreover, work on reinforcement learning and multimodal collaboration shows the importance of dynamic adaptability in robot behavior, highlighting the limitations of fixed policies [2]. Our framework builds upon these insights, introducing an architecture to operationalize scalable robot intelligence: cloud, marketplace, user interface, and robot execution.

B. System Architecture

The cloud layer provides the backbone for scalable computation, storage, and communication. It leverages cloud services for training and deploying AI models, Object Storage Service (OBS) for handling datasets and skill repositories, API Gateway for secure service exposure, and Huawei Cloud Container Engine (CCE) for orchestrating containerized services. This architecture ensures that skill updates and improvements are distributed efficiently across a wide fleet of robots. As demonstrated in drone research, simulation and cloud-driven reinforcement learning provide a safe, cost-effective environment for testing before deployment to physical robots [3]. In the same way, our cloud layer ensures rapid iteration without jeopardizing hardware. The marketplace layer enables modular sharing and distribution of robot skills. It offers both public repositories, where skills can be freely shared across organizations, and private repositories, where proprietary solutions can be managed internally. Three deployment modes are supported: Rent, Buy, and Rent-to-Buy. Renting provides affordable, flexible access for small and medium enterprises, while purchasing ensures long-term integration for large enterprises. Rent-to-Buy allows organizations to test new skills in practice before committing. This marketplace approach mirrors advances in modular robotics for manufacturing, where generalizable and reconfigurable robot skills allow more efficient task allocation and reuse across workflows [4]. By extending this concept to a cloud-enabled marketplace, our system democratizes access to robot intelligence, much as application stores revolutionized software ecosystems. The user interface layer provides a dashboard that allows operators to install, configure, and schedule robotic skills without programming knowledge. Through an intuitive web-based environment, businesses can monitor performance, assign tasks, and update skill sets in real time. This reduces reliance on developers and allows non-technical staff to manage robots effectively. In line with research on multimodal interaction managers, where robots must flexibly interpret and act upon multimodal inputs such as speech or gestures [2], our UI ensures that humans can guide and adapt robots` behavior. The robot layer focuses on local skill execution and low-latency response. Robots download skills from the marketplace and run them using onboard computing resources. This ensures autonomy and responsiveness even without constant cloud connectivity. Huawei's 5G infrastructure provides reliable communication with the cloud and user dashboard, supporting fast synchronization of updates and monitoring. The emphasis on local execution aligns with findings from reinforcement learning and robotics research, where real-time responsiveness and robust interaction with humans are essential for effective task completion [2, 3]. By combining local processing with cloud-assisted updates, the system achieves both flexibility and robustness.

III. Conclusion

This paper introduced Robot Skills-as-a-Service, a modular and scalable framework designed to overcome the rigidity and high integration costs of traditional robotic systems. By integrating four layers - cloud, marketplace, user interface, and robot execution - the framework enables businesses to install, configure, and share robotic skills without coding. The architecture supports flexible deployment models and ensures both scalability through cloud services and responsiveness through local execution. Real-world use cases across logistics, healthcare, hospitality, and manufacturing highlight the potential of this approach to reduce costs, shorten deployment times, and broaden access to advanced robotic capabilities. By bridging cloud-based intelligence with practical robot execution, our solution represents a step toward more adaptable and reusable robotic ecosystems.

Acknowledgment

The authors gratefully acknowledge the support of the Huawei Seeds for the Future program and the opportunity to participate in a practical study trip to China.

References

[1] Zhang, R., Zhou, Y., Zhang, J. *et al.* Cloud-integrated robotics: transforming healthcare and rehabilitation for individuals with disabilities. *Proc.Indian Natl. Sci. Acad.* **90**, 752–763 (2024). https://doi.org/10.1007/s43538-024-00264-3

[2] Mehri Shervedani, A., Li, S., Monaikul, N. *et al.* Multimodal Reinforcement Learning for Robots Collaborating with Humans. *Int J of Soc Robotics* (2025). https://doi.org/10.1007/s12369-025-01287-6

[3] Chan, J.H., Liu, K., Chen, Y. *et al.* Reinforcement learning-based drone simulators: survey, practice, and challenge. *Artif Intell Rev* **57**, 281 (2024). https://doi.org/10.1007/s10462-024-10933-w

[4] Bai, Y. (2025). Introduction to Reinforcement Learning. In: AI Foundations and Applications with MATLAB. Springer, Cham. https://doi.org/10.1007/978-3-031-84423-2_9

Ulysseus R&I Conference 2025
Navigating Pathways:Digital Transformation of Industry
20 October 2025, Košice, Slovak Republic

Audiovisual, Design, and Interactive Media Laboratory: A case study.

Belen Cisneros
MSc Smart EdTech
Université Côte D'Azur (Student)
Lerma, Mexico
ORCID 0000-0003-2829-7961

***Abstract*— Universities are increasingly recognized as key drivers of digital innovation, extending beyond traditional education to become active catalysts of industry transformation. This research examines LADMI (Audiovisual, Design, and Interactive Media Laboratory) as an exemplary case study of university-led educational technology incubation. Developed through strategic collaboration between academia, municipal governments, and local schools, LADMI employs a novel living lab methodology that combines User Experience research with Instructional Design to address real educational challenges in marginalized communities.**

The laboratory's interdisciplinary approach, integrating serious game design, learning analytics, and accessibility-focused development, demonstrates how universities can effectively bridge the gap between research innovation and market-ready solutions. This case study provides a replicable framework for higher education institutions seeking to establish innovation ecosystems that generate both commercial value and social impact within the growing global EdTech market.

Keywords— living labs, edtech, university incubators, innovation hubs, media education.

I. Introduction

Belén Cisneros developed LADMI as part of her self-employment master's internship at the Université Côte D'Azur while working as a temporary full-time associate professor in the Autonomous Metropolitan University at bachelor's programme in Education and Digital Technologies in Lerma de Villada, State of Mexico, Mexico.

The main objective of the LADMI development was to present a novel model of interdisciplinary collaboration that integrates serious game design, learning analytics, and user experience research within a university-based innovation ecosystem. Operating within this significant market opportunity, this research explores critical insights into the scalability and replication potential of university-led incubators. The LADMI model addresses the Mexican educational technology market, valued at $635.7 million in 2022 and projected to reach $966.2 million by 2026, while simultaneously tackling digital literacy gaps in marginalized communities. (ICEX, 2023)

The LADMI's approach integrates multiple digital technologies including gamification, interactive media design, and accessibility-focused development to create freely accessible educational resources. Through strategic partnerships with municipal and state governments, LADMI aims to develop a sustainable funding model that combines public scholarships, crowdfunding, and strategic alliances while maintaining its commitment to universal access to quality education.

The laboratory's interdisciplinary team structure, combining students, graduates, and faculty members, creates a sustainable pipeline for innovation that benefits both academic development and industry advancement.

This case study demonstrates that university-led educational technology incubators can successfully balance commercial viability with social impact, creating a replicable framework for other institutions seeking to enhance their role in digital transformation. As universities increasingly serve as driving forces of digital innovation beyond their traditional educational role, this living lab-based model offers significant implications for higher education institutions worldwide, providing a pathway to become active contributors to the digital economy while maintaining their educational and social mission.

II. University Incubators

A. Living labs

One of the common definitions of living labs reads: "The Living Lab(oratory) inspires as a notion, a setting, and a methodology encouraging participatory approaches to the co-production of knowledge for innovation and transformation". (J. Backhaus, et al. 2023) Living labs primarily emerge from Human Computer Interaction (HCI) context, but they have been driven to more transdisciplinary approaches. The main structure of a living lab is the capability of experiment and solve problems from the real world. One great example of it, is the Media Lab from the Massachusetts Institute of Technology (MIT), as one of its most striking projects is Scratch, a platform that allows video game creation in a simple, intuitive, and accessible environment. (F. Champika, 2019)

B. LADMI as a living lab environment

The living lab-based strategy in LADMI confronts university students with learning problems in the real world by connecting the educational digital content they develop with the end user: a group of students from one of the 223 schools, serving approximately of 42,848 of school population (Data México, 2024) in Lerma de Villada, a municipality from the State of Mexico. Most of these schools are based on rural environments, so they commonly lack technological resources, such as computer-equipped classrooms, internet access, computer-trained staff, and some even lack electricity.

C. Content production pipeline

LADMI employs a hybrid UX-ID (User Experience-Instructional Design) methodology that combines user-centered design principles with systematic instructional development frameworks. This methodology, developed by Cisneros, integrates usability research techniques with ADDIE model components to create contextually appropriate educational technologies.

Over 11 weeks, 30 students organized into six interdisciplinary teams produced 12 digital educational resources spanning multiple formats (video games, animations, videos, interactive presentations, and application prototypes) and target demographics (children, adolescents, and adults). All content is freely accessible through the project website.

The process involves five key stages: establishing school partnerships and conducting comprehensive needs assessment through stakeholder surveys and classroom observation; collaboratively developing targeted digital content with integrated skills training in graphic design, interaction design, and audiovisual production; implementing solutions through controlled classroom interventions that compare traditional and technology-enhanced approaches; and evaluating outcomes through pre/post assessments measuring both learning gains and user satisfaction.

D. Results

Prior to the Lab's formation, several digital projects had been developed at the UAM using a similar methodology. However, the need to create a formal methodological process and the opportunity to provide real-world follow-up on student projects were key factors in formalizing the Lab.

The LADMI hybrid UX-ID methodology has been validated through pilot implementations. For instance, a 17-lesson interactive guide targeting digital literacy for older adults in Xonacatlán achieved high user satisfaction, with participants reporting increased digital confidence and social connectivity, demonstrating the framework's applicability across diverse demographics. (V. Castañeda, et al. 2024)

E. Limitations

A significant limitation affecting the project's scalability relates to institutional formalization challenges. Despite demonstrated success, the laboratory has not achieved formal university recognition, limiting access to institutional funding mechanisms, student scholarship programs, and long-term sustainability resources. This highlights broader challenges in university innovation ecosystems, particularly regarding the integration of experimental methodologies within traditional academic structures. The temporary nature of the principal investigator's academic appointment further constrained the project's institutional embedding and continuity planning. These structural limitations underscore the importance of institutional commitment and formal support mechanisms for university-led innovation initiatives.

III. Conclusion

This research contributes to the growing body of knowledge on university-led innovation ecosystems by demonstrating how academic institutions can effectively transition from traditional knowledge producers to active catalysts of digital transformation. The LADMI case study provides three significant contributions to the field:

First, it validates the hybrid UX-ID methodology as an effective framework for developing contextually relevant educational technologies in resource-constrained environments. The integration of user experience research with systematic instructional design proves particularly valuable when addressing the complex needs of marginalized communities.

Second, the study demonstrates the viability of interdisciplinary collaboration models that benefit both academic development and community impact. The 30-student, 6-team structure created sustainable knowledge transfer while producing 12 functional digital resources, suggesting this model's potential for replication.

Third, LADMI's partnership approach with municipal governments and local schools offers a scalable framework for addressing the digital divide in developing countries, particularly relevant given Mexico's projected EdTech market growth to $966.2 million by 2026.

Acknowledgment

The author thanks Dr. Oscar Hernandez Razo for academic guidance and the participating schools in Lerma municipality for their collaboration. This work was supported by LADMI students and developed in partnership with local educational institutions.

References

[1] B. Cisneros, “UX-ID Methodology”, 2024, unpublished.

[2] Data México, “Lerma”, 2024, Gobierno de México.

[3] F.Champika. “Introducing Scratch 3.0: Expanding the creative possibilities of coding” 2019, Massachusetts Institute of Technology

[4] ICEX, “El mercado de la tecnología educativa (EdTech) en México”, 2023, Oficina Económica y Comercial de la Embajada de España en Ciudad de México.

[5] J. Backhaus, S. Böschen, S. John, A. Altepost, F. Cloppenburg, F. Fa hy, J. Gäckle, T. Gries, C. Heckwolf, K. Matschoss, “Living lab”, Handbook transdisciplinary Learning, 2023, pp. 235-244

[6] V. Castañeda, C. González, D. Hernández, “Návega fácil: Adultos mayores más conectados, 2024, Universidad Autónoma Metropolitana unidad Lerma, p. 12.

[7] M. Hassenzahl, “User Experience and Experience Design”, The Encyclopedia of Human-Computer Interaction, 2nd Ed.

[8] A, Bates, “Teaching in a Digital Age”, 2022, 3rd Ed. Pressbooks.

Ulysseus R&I Conference 2025
Navigating Pathways:Digital Transformation of Industry
20 October 2025, Košice, Slovak Republic

Empowering Digital Leaders through BIPs and COILs: Good Practices for Global Skills Development in Higher Education

Juan Luis Blanco-Guzmán[1]
[1]Instituto Andaluz de Investigación e Innovación en Turismo (IATUR), Universidad de Sevilla
Seville, Spain
jbguzman@us.es

Jeisson Alexander Higuera Reina[1]
[1]Instituto Andaluz de Investigación e Innovación en Turismo (IATUR), Universidad de Sevilla
Seville, Spain
jhiguera1@us.es

***Abstract*— In an increasingly interconnected world, higher education institutions must prepare students and staff to thrive in global, digital environments. This paper explores the potential of Blended Intensive Programmes (BIPs) and Collaborative Online International Learning (COIL) as key instruments to foster internationalisation, digital skills, and intercultural competences. Based on experiences within the Ulysseus European University alliance, it shows how these initiatives democratise access to international experiences, support professional development for staff, and enhance institutional strategies for internationalisation and digital transformation.**

Keywords*— *internationalisation, higher education, BIPs, COIL, digital competences, Ulysseus

I. Introduction

Internationalisation has evolved from being an optional component to a strategic necessity in higher education [1]. Traditional approaches based on physical mobility face challenges of cost, accessibility, and sustainability [2]. The European Commission launched BIPs within Erasmus+ 2021–2027 to combine short-term physical mobility with collaborative virtual work, reducing barriers for students with fewer opportunities [3]. Similarly, COIL integrates intercultural collaboration directly into curricula through joint teaching and virtual teamwork between students from different countries [4]. These formats enable “internationalisation at home”, broadening participation and fostering inclusive access to global learning [5].

II. BIPs and COIL as Drivers of Internationalisation

A. Benefits for students:

Empirical evidence shows that BIPs and COIL effectively build intercultural, digital, and teamwork competences. A quasi-experimental study with 330 students from the Netherlands and the United States found significant increases in intercultural competence among COIL participants using the Cultural Intelligence Scale [6]. BIPs implemented by the EU GREEN Alliance led students to develop curiosity, openness, creativity, and collaborative problem-solving skills [7]. Such initiatives strengthen employability by cultivating transversal skills highly valued in the labour market (adaptability, digital literacy, critical thinking, and communication) [8]. They also expand access to international experiences, fostering equity by involving students who cannot afford long-term mobility [9].

B. Benefits for staff.

For lecturers, these formats provide opportunities for pedagogical innovation, cross-border collaboration, and professional development. Teaching collaboratively in BIPs and COIL projects enables staff to exchange methodologies, co-create materials, and enhance their intercultural teaching skills [10]. More than 70% of Erasmus+ staff mobilities report gaining new skills and good practices applicable at their home institutions [11]. Faculty involved in COIL also highlight benefits such as international networking, new teaching approaches, and motivation from contributing to students’ global growth [12].

C. Institutional impact.

Implementing BIPs and COIL aligns with institutional internationalisation strategies, enhances global visibility, and accelerates digital transformation. The European Commission reports that European Universities alliances have expanded mobility opportunities, created joint programmes, and shared infrastructures and expertise across countries [13]. These initiatives act as catalysts for institutional change, driving digital innovation, improving administrative processes, and embedding internationalisation into curricula [14]. They enable universities to pool resources and become more resilient, collaborative, and competitive.

III. Ulysseus as a Catalytic Ecosystem

Alliances such as Ulysseus European University exemplify how institutional networks can catalyse BIPs and COIL implementation. Ulysseus integrates eight universities, 225,475 students and 24,415 staff across Europe [15]. Its Innovation Hubs on themes such as Ageing

& Wellbeing, Applied Artificial Intelligence for Business & Education, Digital Transformation of Industry, Sustainable Entrepreneurship & Impact, facilitate interdisciplinary, challenge-based BIPs and foster teacher collaboration [16]. Research shows that Ulysseus has systematically developed joint programmes and academic recognition processes to support cross-border education [17]. By providing infrastructure, credit recognition agreements, and governance frameworks, alliances like Ulysseus remove barriers that often hinder international collaboration [14].

IV. Conclusion

BIPs and COIL are not alternatives to traditional mobility but essential components of a comprehensive, inclusive, and sustainable internationalisation strategy. They foster intercultural competence, digital skills, and global mindsets at an unprecedented scale, while simultaneously supporting staff development and institutional innovation. Backed by structural alliances like Ulysseus European University, these initiatives can transform European higher education and prepare students and staff to become digital leaders ready to tackle 21st-century global challenges.

Drawing from my own experience as a participant, lecturer, coordinator, and organiser in several BIPs developed in collaboration with various Ulysseus European University partner institutions, I can attest to the profound advantages and opportunities they create. These programmes have demonstrated tangible benefits for students (enhancing their employability and intercultural competences) while empowering staff to innovate pedagogically and expand their international networks. Moreover, they open unprecedented possibilities for individuals and institutions who, due to economic, geographical, or structural constraints, might otherwise never have been able to internationalise their education. By lowering traditional barriers and embedding collaboration into digital and physical environments, BIPs and COIL pave the way towards a more inclusive and globally connected higher education ecosystem.

References

[1] Knight, J. (2004). Internationalization remodelled: Definition, approaches, and rationales. Journal of Studies in International Education, 8(1), 5–31.

[2] O'Dowd, R., & Werner, S. (2020). The first steps of blended mobility in European higher education. Journal of Studies in International Education, 24(3), 347–364.

[3] European Commission. (2023). Erasmus+ Programme Guide 2021–2027. Publications Office of the European Union.

[4] Guth, S., & Rubin, J. (2015). The guide to COIL virtual exchange. SUNY COIL Center.

[5] Rubin, J. (2017). Embedding collaborative online international learning at higher education institutions. Internationalisation of Higher Education, 2, 27–44.

[6] Hackett, S., Janssen, J., Beach, P., Perreault, M., Beelen, J., & van Tartwijk, J. (2023). The effectiveness of COIL on intercultural competence development in higher education. International Journal of Educational Technology in Higher Education, 20(5).

[7] EU GREEN Alliance. (2023). The 2022–2023 EU GREEN BIP experience.

[8] Beniusiene, L., et al. (2022). Experiential learning in international cooperation: Insights from Erasmus+ BIP mobility. EDULEARN22 Proceedings.

[9] Gögele, C., & Kletzenbauer, P. (2022). Blended intensive programmes: Promoting internationalisation in higher education. END Conference.

[10] Jager, S. (2021). The case of Erasmus+ blended intensive programmes within European University Alliances. In Internationalisation of European Higher Education.

[11] YERUN. (2024, May 22). The significance of Erasmus+ in universities: Impact on mobility, staff development and BIPs.

[12] Kučerová, K. (2023). Benefits and challenges of conducting a COIL class. International Journal on Studies in Education, 5(2), 193–212.

[13] European Commission. (2024). European Universities Initiative: Outcomes and transformational potential.

[14] Fedak, V., Hudak, M., & Jakab, F. (2022). Best practice for boosting innovation in the HEI through the initiative of European University Alliances. 17th International Conference on Emerging eLearning Technologies.

[15] Ulysseus. (2024). About us: Who we are. https://ulysseus.eu/about-us/who-we-are/

[16] Lassila, M., & Ohinen-Salvén, M. (2023). Teacher collaboration in the international partner network. Theseus.

[17] Mäkelä, K. (2023). Academic recognition process—Implementing "bricolage" to analyse development in the Ulysseus European University alliance. European Journal of Education Studies.

Ulysseus R&I Conference 2025
Navigating Pathways:Digital Transformation of Industry
20 October 2025, Košice, Slovak Republic

Digitalisation as a Driver of Internationalisation in University-Based Teacher Education: Exploring Challenges, Opportunities and Models of Innovation in the digital Era

Schmider Christine
Department of foreign languages,
University Côte d'Azur
LINE (Laboratoire Numérique et d'Innovation pour l'Education)
Nice, France
christine.schmider@univ-cotedazur.fr

***Abstract*—Internationalising teacher education is a key challenge in today's globalised world and a strategic responsibility for European universities and political stakeholders. As diversity becomes a defining feature of societies, initial teacher education must integrate international perspectives and digitally supported approaches to prepare future teachers for heterogeneous classrooms. The post-COVID era has accelerated the emergence of digital pathways for embedding global perspectives. This paper presents a modular digital platform designed for transnational virtual teacher education. It combines an open information portal, a cooperation hub, and a teaching and learning space, complemented by an e-portfolio system and formats such as e-tandems, COIL projects, and Blended Intensive Programmes (BIPs). Together, these elements illustrate how digital transformation can foster sustainable and practice-oriented internationalisation in teacher education, aligning with the ambition of the Ulysseus R&I Conference *Navigating Pathways: Digital Transformation of Industry*, and in particular Track 2, which highlights universities as drivers of digital innovation**

Keywords—Teacher education, internationalisation, digitalisation, virtual exchange

I. Introduction

Teacher education remains a decisive factor in the quality of education systems, yet it often lags behind in terms of internationalisation. The European Union's new Strategic Framework for Education and Training 2021–2030 highlights the need to strengthen quality and efficiency in education by enhancing teachers' competences [1]. Universities therefore carry the dual responsibility of preparing future teachers and driving digital innovation in this field. In a context of increasing diversity, transnational collaboration and intercultural competences are no longer optional but essential. Digitalisation has become a catalyst for these developments, providing scalable and inclusive pathways to embed international perspectives into teacher education [2]. The Université Côte d'Azur has been a key actor, engaging in European networks and coordinating digital cooperation projects that contribute to rethinking teacher education in international terms. While teacher education often remains regionally focused, universities should develop collaborative approaches that integrate international perspectives into structures and pedagogical models. The digital platform presented here reflects this ambition. It not only supports visibility, transparency, and access to networks, but also provides a closed environment for inter-institutional collaboration and a semi-open arena for joint teaching and learning.

By embedding internationalisation 'at home', the model reduces structural barriers to mobility and creates inclusive opportunities for all students [3]. The platform also integrates a digital portfolio, enabling students to document intercultural learning outcomes and reflect on their professional development. These elements contribute to sustainable internationalisation and resonate with the ambition of the Ulysseus R&I Conference *Navigating Pathways: Digital Transformation of Industry*, particularly Track 2, which underlines the role of universities as key drivers of digital innovation and collaborative transformation.

II. Conceptualising Digital Pathways for Internationalising Teacher Education

A. From Digital Tools to Pedagogical Paradigms

Digital infrastructures are increasingly recognised as enablers of internationalisation in higher education. Rather than viewing them merely as technical tools, this presentation theorises platform-based approaches as a new paradigm for teacher education. The objective is to demonstrate how digital environments can move beyond logistical support to become conceptual frameworks that foster intercultural exchange, collaborative curriculum design, and the sustainable integration of global perspectives into teacher training.

The platform developed within the German-French University framework and broader European teacher education networks addresses this challenge through three interconnected modules:1. An Information Portal: an open-access site offering visibility, transparency, and easy access to resources, programmes, and international networks. 2. A Cooperation Hub: a secure digital environment enabling joint curriculum development, inter-institutional collaboration, and shared research activities. 3. A Teaching and Learning Space: a semi-open arena for hosting innovative formats such as e-tandems, COIL projects, and BIPs. Additionally, the platform integrates an e-portfolio system, allowing student teachers to document intercultural learning outcomes, reflect on professional development, and showcase competences to prospective employers. These three modules are interlinked: the information portal encourages participation; the cooperation hub fosters concrete outputs; and the teaching and learning space provides the arena for experimentation and pedagogical innovation.

The initiative has been supported and co-piloted at Université Côte d'Azur, which plays a central role in bringing together academic staff, student teachers, and institutional partners from across Europe. This positioning underlines the university's commitment to both educational innovation and strategic internationalisation.

B. Operationalising Digital Internationalisation through Virtual Exchanges

Beyond its conceptual design, the platform has been applied in a variety of innovative teaching and learning contexts, with e-tandems representing one of the most effective formats. Building on the French-German tradition of tandem learning [4], these digital tandems connect student teachers from different universities and cultural backgrounds in structured, task-based collaborations. Working in pairs or small groups, students engage in reciprocal exchanges combining linguistic practice with professional reflection on pedagogical challenges. The use of digital portfolios ensures that these experiences are not limited to isolated interactions but become integrated into broader professional development pathways.

In recent years, the platform has also hosted virtual colloquia, COIL modules, and Blended Intensive Programmes (BIPs). For example, transnational tandems have explored themes such as urban semiotics, intercultural literature, or digital media in education, producing joint audiovisual projects and academic outputs. These experiences demonstrate that internationalisation "at home" can be embedded into the regular curriculum, fostering competences such as intercultural sensitivity, digital literacy, and reflective practice. Moreover, the structured and institutionalised nature of these exchanges—supported by the Ulysseus Alliance and European funding instruments—ensures their sustainability and scalability. In this way, the platform transforms abstract ambitions of digital internationalisation into everyday pedagogical practice that directly benefits both students and educators. By fostering collaborative knowledge-building and shared professional reflection, the platform also contributes to the emergence of digital communities of practice [5], strengthening the long-term professionalisation of future teachers

C. Innovation, Ecosystem and Transferability

The platform enhances educational ecosystems by fostering collaboration among universities, schools, NGOs, and local education authorities. Its modular design makes it adaptable to different institutional contexts and transferable to other disciplines beyond teacher education.

Importantly, the platform is not conceived as a stand-alone tool but as part of a larger innovation ecosystem. It complements Erasmus mobility programmes by offering inclusive opportunities for those unable to travel, and it aligns with European initiatives such as the Digital Education Action Plan. Partnerships with regional authorities and educational technology providers further extend its reach, making it a showcase for how universities can position themselves as active drivers of digital transformation. In addition, the platform has been tested in Blended Intensive Programmes, where physical mobility is combined with sustained virtual cooperation, offering a scalable model that could be applied across disciplines.

III. Conclusion

Digitalisation offers a unique opportunity to rethink teacher education as a driver of internationalisation. The presented platform demonstrates how universities can lead this transformation by creating infrastructures that foster global collaboration, develop competences for the digital age, and strengthen links between research, practice, and innovation. Such approaches directly reflect the goals of Track 2: positioning universities as engines of digital innovation and sustainable knowledge transfer.

The experience of Université Côte d'Azur illustrates how a research-intensive university can leverage its institutional strengths and international partnerships to act as a driver of digital innovation within teacher education and beyond. Future directions include expanding the platform to other subject areas, strengthening links with industry and civil society, and assessing long-term impacts on teaching quality and employability of graduates.

Acknowledgment

The author gratefully acknowledges the support of the German French University (DFH-UFA) and the Ulysseus European University Alliance for enabling the development of digital cooperation projects in teacher education. Special thanks are extended to the colleagues from the Direction du Développement International et Europe (DDIE) at Université Côte d'Azur for their invaluable support and assistance.

References

[1] Council of the EU, "Strategic Framework for Education and Training 2021–2030," 2021. [Online]. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32021G0226(01).

[2] Y. Punie and C. Redecker, European Framework for the Digital Competence of Educators: DigCompEdu. EUR 28775 EN. Luxembourg: Publications Office of the European Union, 2017.

[3] B. Leask, Internationalizing the Curriculum. Abingdon, UK: Routledge, 2015.

[4] M. Bechtel, Interkulturelles Lernen beim Sprachenlernen im Tandem: Eine diskursanalytische Untersuchung. Tübingen, Germany: Narr, 2003.

[5] E. Wenger, Communities of Practice: Learning, Meaning, and Identity. Cambridge: Cambridge University Press, 1998.

Ulysseus R&I Conference 2025
Navigating Pathways:Digital Transformation of Industry
20 October 2025, Košice, Slovak Republic

Unlocking the Invisible Museum: Digital Innovation and Policy Advocacy in the Protection of Adriatic Underwater Heritage

Darko Kovacevic
Center of Archaeology
University of Montenegro
Podgorica, Montenegro
darkok@ucg.ac.me

Abstract*— The Adriatic Sea contains a vast collection of historical remains, forming an invisible museum largely inaccessible to the public. Through technological research and multilateral cooperation, universities are emerging as pivotal forces in driving digital innovation and shaping policy for cultural heritage protection. A compelling case study of the University of Montenegro shows how its leadership of the multilateral Interreg-funded Wrecks4All project catalysed a systematic transformation in the awareness, documentation, and protection of the country's Underwater Cultural Heritage (UCH). Through a comprehensive, methodologically grounded approach, the University of Montenegro team conducted a project focused on digital documentation and public outreach to communicate the value of UCH and the necessity of its preservation. The project leveraged advanced technologies, including remote sensing, 3D photogrammetry, Virtual and Augmented Reality, GIS, and mobile applications, to create an unprecedented means of engagement with previously inaccessible sites. This process culminated in the establishment of a Virtual Reality showrooms, which made UCH accessible to the public, and the creation of a GIS digital inventory. This inventory serves as a crucial informational and management tool for informed decision-making and the formal legal protection of submerged resources. Through attractive VR scenarios and 3D digital twins of UCH, the Wrecks4All project's strategic objective was to influence policy and institutional behaviour. Stakeholder engagement and capacity-building activities empowered national institutions to adopt digital technologies and consider aligning domestic legal frameworks with international standards. This project led to the establishment of a dedicated academic research unit at the university, focused on the digital preservation of heritage sites, thereby ensuring the initiative's sustainability. The project demonstrates how digital tools can be used both for scientific research and as a dynamic mechanism for policy advocacy and the long-term stewardship of cultural resources, fostering a proactive and sustainable system for UCH management.

Underwater cultural heritage, photogrammetry, virtual reality, GIS, public outreach

I. Introduction

The depths of the Adriatic Sea conceal a vast and largely inaccessible repository of human history, a veritable invisible museum. In Montenegro, this Underwater Cultural Heritage (UCH) spans epochs from Hellenistic voyages to 20th-century military engagements. [1][2] For decades, its protection has languished due to institutional shortcomings. [3] The University of Montenegro's Wrecks4All project has demonstrated how digital innovation can be a powerful instrument for policy advocacy and long-term stewardship. [4] This initiative provides a compelling case study for transforming heritage research into an impactful and sustainable management framework.

II. Transforming Montenegro's Underwater Cultural Heritage from Invisible to Institutionalized

A. *The Invisible Museum: A Contextual Analysis of Montenegro's Underwater Cultural Heritage*

Montenegro's UCH holds significant value, but maritime archaeology as a scientific discipline remained underdeveloped for decades. This stagnation stemmed from the absence of a functional institutional framework for its research and protection, which contributed to the occasional looting of UCH sites and left these resources vulnerable. [3]

While Montenegro formally recognized its UCH by ratifying the UNESCO 2001 Convention, its implementation was hindered by institutional and legislative confusion and unclear responsibilities among various government bodies. Prior to the Wrecks4All project, efforts to survey the region's maritime past were primarily initiated by foreign institutions. These endeavours, while advancing knowledge, failed to foster the development of national research capacities or establish consistent domestic practices for UCH protection. [3] The Wrecks4All project was thus a direct response to entrenched systemic ambiguities. Its strategic design was predicated on the understanding that a durable solution could only be achieved by addressing these institutional and legal challenges, rather than simply conducting another temporary archaeological survey. [5]

B. *A New Paradigm: The Wrecks4All Project as a Catalyst for Change*

The Wrecks4All project was developed to address the regionally unbalanced tourism valorisation and protection of underwater cultural heritage. This collaborative approach marked a departure from the previously unsustainable efforts. The project demonstrated the power of multilateral cooperation and a holistic, cross-disciplinary methodology. Over its three-year implementation period, it adopted a comprehensive, methodologically grounded approach that encompassed a multi-faceted strategy: digital documentation, public outreach, stakeholder engagement, and targeted policy advocacy. [4][5]

This integrated model was crucial because it allowed the project to tackle the problem from multiple angles simultaneously. For instance, the creation of digital models and VR scenarios was not an isolated academic pursuit; it was designed to be a tool for raising public awareness, which in turn would create support for policy change. The objective was to influence stakeholders and decision-makers about the necessity of applying the provisions of the UNESCO 2001 Convention, to raise awareness and to empower expert capacities of national institutions. [5][6]

C. Technological Transformation: From Inaccessible to Engaging

The strategic application of advanced digital technologies was a cornerstone of the Wrecks4All project's methodology. The project leveraged a digital toolbox including 3D photogrammetry, Virtual and Augmented Reality, GIS, and mobile applications to create means of engagement with previously inaccessible sites. These technologies served a vital scientific purpose: to create precise and detailed documentation. The project team used 3D photogrammetry to create high-fidelity 3D digital twins of UCH, which could be studied remotely and digitally preserved. Similarly, a comprehensive GIS digital inventory was established, transforming disparate historical data into a crucial informational and management tool for informed decision-making and the formal legal protection of submerged cultural resources. [4][5]

The project's strategic objective, however, extended beyond mere scientific documentation. The technological outputs were leveraged as a mechanism for policy advocacy and public engagement. For example, while 3D photogrammetry produced high-resolution digital twins of UCH sites, it also provided a tangible representation of inaccessible heritage for stakeholders and the public. The establishment of Virtual Reality showrooms, featuring attractive VR scenarios, was not merely for public enjoyment; it served as a powerful tool to make the "invisible museum" visible and tangible to a broad audience. By allowing the public to virtually explore and experience these submerged sites, the project effectively communicated the value of UCH and the necessity of its preservation in a way that traditional, static methods could not. [5]

D. From Inventory to Advocacy: The Project's Policy and Institutional Impact

One of the project's accomplishments was its direct influence on institutional and policy-making processes. Over its three-year course, the project's strategic engagement and capacity-building activities empowered national institutions to adopt digital technologies and actively consider aligning their legal frameworks with international standards, such as those of the UNESCO 2001 Convention. A key instrument of this influence was the analytical study, which assessed the precise state of UCH protection in Montenegro. This study provided a factual basis for the subsequent development of an Action Plan designed to enhance the protection system by promoting institutional cooperation and creating synergies. [4][5][6]

This process illustrates a critical translation of scientific research into concrete policy. The GIS digital inventory which informed The Spatial Plan of Montenegro is a foundational tool for the formal legal protection of submerged resources. By providing a clear, data-driven understanding of the challenges and by offering a well-defined Action Plan, the project gave decision-makers a clear path forward. [5]

E. The Path to Sustainability: Fostering a Proactive UCH Management System

The most lasting outcome of the Wrecks4All project is the establishment of the country's first academic research unit dedicated to underwater cultural heritage at the University of Montenegro. [4] This singular achievement represents a fundamental paradigm shift. Previously, UCH projects were externally driven and failed to build durable domestic capacity and structure. This move institutionalizes the capacity-building processes and research momentum initiated by the project. [5] It moves beyond the temporary nature of grant-funded projects to create a self-sustaining system for UCH research. This outcome demonstrates that the project's success is not just measured in its digital outputs but in its ability to create a lasting infrastructure for continued progress. [4]

III. Conclusion

A. A Model for Global Heritage Stewardship

The Wrecks4All project, led by the University of Montenegro, provides a compelling and insightful model for the protection of cultural heritage in the 21st century. It successfully navigated a complex landscape of institutional voids, legal ambiguities, and public unawareness by adopting a strategic, holistic approach that combines technological innovation with targeted institutional and policy advice. The project's success lies in its ability to use digital tools not as an end in themselves, but as a mechanism for both scientific research and policy advocacy.

Acknowledgment

The University of Montenegro, as the lead partner, gratefully acknowledges the support of the funding bodies Interreg IPA Croatia–Bosnia and Herzegovina–Montenegro and Interreg IPA South Adriatic for their commitment to the Wrecks4all initiative. Sincere appreciation is also extended to all project partners for their dedicated collaboration and the exemplary implementation of project activities.

References

[1] D. Gačević, Podmorje Crne Gore. Herceg Novi: Matica crnogorska, 2012.

[2] G. Karović, "Podvodna arheološka nalazišta crnogorskog podmorja," Godišnjak Pomorskog muzeja u Kotoru, vol. LV–LVI, pp. 425–459, 2007–2008.

[3] R. MacKintosh, "Capacity in maritime archaeology: A framework for analysis," Journal of Maritime Archaeology, vol. 14, pp. 391–408, 2019.

[4] D. Kovačević, "Immersive technology's role in the development of maritime archaeology in Montenegro," Submerged Heritage, vol. 13, pp. 67–70, 2023.

[5] D. Kovačević, "Bottom-up approach towards systematic management of underwater cultural heritage in Montenegro," in Il Progetto UnderwaterMuse. Atti del Convegno Internazionale "Stati generali della gestione dal basso del patrimonio subacqueo", R. Auriemma, Ed. Bari: Edipuglia, 2024, pp. 95–98.

[6] A. Firth, Managing Shipwrecks. Fjordr Limited for the Honor Frost Foundation, 2018, p. 44.

Ulysseus R&I Conference 2025
Navigating Pathways:Digital Transformation of Industry
20 October 2025, Košice, Slovak Republic

Algorithmic Governance and Strategic Recovery in the Airline Industry

Jeisson Alexander Higuera Reina[1]
[1] Instituto Andaluz de Investigación e Innovación en Turismo (IATUR), Universidad de Sevilla
Seville, Spain
jhiguera1@us.es

Juan Luis Blanco Guzmán[1]
[1] Instituto Andaluz de Investigación e Innovación en Turismo (IATUR), Universidad de Sevilla
Seville, Spain
jbguzman@us.es

Abstract: The COVID-19 pandemic exposed striking differences in how airlines managed operational disruptions and strategic recovery. This study examines how artificial intelligence enhances firm-level decision-making through Algorithmic Governance. Drawing on data from over 3,400 airlines (2019-2023), we develop Contextually Embedded Dynamic Capabilities. Our findings show AI effectiveness depends on cultural and institutional context. We introduce the XAI Neurocognitive framework integrating TADE (Task-Directed Attention), MCCE (Cognitive Efficiency), and TCV (Trust through Visualization). This framework positions AI explanations as "extended cognitive artifacts" aligning with human attention patterns and trust-building mechanisms. XAI-supported strategies outperform opaque systems in high-stakes environments.

Keywords: *Algorithmic governance, Explainable AI, Strategic resilience, Airline industry, Cultural context*

I. Introduction

The airline industry's digital transformation has accelerated dramatically. Yet the simple adoption of AI does not guarantee strategic success. This paper explores how airlines leverage AI as a source of strategic resilience through Algorithmic Governance. This approach embeds AI within core decision-making processes while remaining responsive to cultural and institutional contexts.

Recent agentic AI developments represent a paradigm shift, combining foundation models with autonomous planning to create "virtual coworkers." Airlines face a fundamental challenge: building trust in AI systems whose decisions users struggle to understand. The field of Explainable AI (XAI) has emerged to address this opacity, seeking to make AI systems more interpretable and trustworthy [1], [2].

We propose Contextually Embedded Dynamic Capabilities as a framework extending the resource-based view [3], incorporating cultural and institutional moderating effects. AI effectiveness varies significantly across cultural contexts. In high uncertainty avoidance cultures, transparency and explainability become critical for user acceptance.

II. The XAI Neurocognitive Framework

2.1. Theoretical Foundation

The XAI Neurocognitive framework conceptualizes AI explanations as "extended cognitive artifacts" [4], [5]. The extended mind thesis suggests cognitive processes extend into the environment through tools that augment human thinking capabilities. These artifacts must synchronize with natural human cognition patterns.

This integration draws on dual-process theory, distinguishing between fast, automatic thinking (System 1) and slow, deliberate thinking (System 2) [6]. Understanding these cognitive systems becomes essential for designing AI explanations that align with natural human information processing patterns.

TADE (Task-Directed and Executed Attention) models how users allocate limited attention when processing AI explanations. Based on attention theory [7], TADE ensures important elements receive greater visual prominence. The attention system operates through three networks: alerting, orienting, and executive control, determining which information receives priority processing during complex tasks. The formal representation is: $A(t,e) = \Sigma_i [w_i(t) \times S(e_i) \times R(e_i,t) \times C(e_i,u) \times \Phi(\text{context})]$

Where $A(t,e)$ represents total attention assigned to element e at time t. The equation considers model weights (w), visual salience (S), task relevance (R), user mental model congruence (C), and contextual facilitators (Φ).

MCCE (Metacognitive and Cognitive Efficiency) optimizes information presentation to minimize cognitive overload while maximizing comprehension. Drawing on cognitive load theory [8], MCCE distinguishes between intrinsic load (inherent concept complexity), extraneous load (design-generated), and germane load (schema construction). The relationship follows: $CCT = f(CI, CE, CG) \leqslant$ Optimal_WM_Capacity (user, context, task)

TCV (Trust and Confidence through Visualization) identifies visual elements that modulate user trust in AI systems. This component builds on research showing that trust formation involves both cognitive and emotional processes. The dual-process nature of human cognition [6] suggests that trust decisions involve both rapid, intuitive judgments and slower, more deliberate evaluations.

2.2. Empirical Application

Our analysis of 3,400 airlines shows that those implementing XAI-supported strategies demonstrated stronger recovery trajectories. This pattern appears particularly pronounced in regions with strong regulatory frameworks. Airlines using XAI for alliance and network decisions showed greater resilience. They built trust with partners, regulators, and customers through transparent decision-making processes.

The framework's practical application involves three steps. First, hierarchical attention distribution based on A(t,e) calculations. Second, cognitive load optimization through structured information blocks. Third, trust signal integration through competence, benevolence, and integrity indicators.

Consider a practical example. Traditional AI systems might recommend a hotel with minimal explanation: "Hotel Plaza recommended based on your preferences." Our XAI Neurocognitive approach restructures this information. The system presents location first (highest attention weight), followed by price-quality ratio, then amenities. Each element includes visual cues and contextual facilitators that reduce cognitive load while building trust.

This approach aligns with the extended mind concept [4], where the AI explanation interface becomes an extension of the user's cognitive apparatus. The interface does not merely display information but actively supports and enhances human decision-making processes.

III. Methodology and Results

This study employs hierarchical linear modeling (HLM) to analyze nested data structures (firms within countries). We combined this with fuzzy-set Qualitative Comparative Analysis (fsQCA) to identify causal configurations leading to resilience. Cultural data from [9], [10], and [11] were integrated with institutional quality measures.

Results confirm that AI effectiveness is moderated by cultural dimensions. Uncertainty avoidance and institutional quality play particularly important roles. Airlines in high uncertainty avoidance cultures showed significantly better performance when implementing XAI-supported governance compared to opaque AI systems ($\beta = 0.34$, $p < 0.001$).

The XAI Neurocognitive framework's three components demonstrated complementary effects. TADE improved decision speed (15% reduction in processing time). MCCE reduced cognitive errors (23% improvement in comprehension accuracy). TCV increased system trust ratings (18% improvement in user confidence scores).

These results align with attention research [7] showing that well-designed interfaces guide attention more effectively than poorly structured ones. The improvements in cognitive efficiency support cognitive load theory predictions about optimized information presentation.

IV. Discussion and Implications

This research demonstrates effective AI adoption requires Algorithmic Governance aligned with cultural, institutional, and cognitive contexts. The XAI Neurocognitive framework provides a systematic approach for designing technically sophisticated yet cognitively compatible AI systems.

The framework addresses a persistent AI deployment problem: technical sophistication often costs human comprehension. Well-designed explanations enhance both performance and trust, supporting the XAI research agenda [1] that seeks interpretable AI without sacrificing performance.

The DARPA XAI program [2] has emphasized creating AI systems whose learned models and decisions humans understand and appropriately trust. Our framework contributes by providing specific design principles grounded in cognitive science.

Key contributions include: (1) empirical evidence for context-dependent AI effectiveness, (2) Algorithmic Governance as strategic management concept, (3) XAI Neurocognitive framework for trustworthy AI systems. For practitioners, this research offers concrete guidelines for building resilient organizations through context-aware AI implementation. The framework provides specific metrics and design principles that development teams implement immediately.

Future research should validate the framework through neuroscientific techniques. Eye-tracking, fMRI, and EEG studies would provide deeper insights into cognitive processing patterns. The airline industry continues evolving in an uncertain world. Organizations that master the balance between AI sophistication and human understanding will thrive.

References

[1] A. Barredo Arrieta *et al.*, “Explainable Artificial Intelligence (XAI): Concepts, taxonomies, opportunities and challenges toward responsible AI,” *Inf. Fusion*, vol. 58, pp. 82–115, June 2020, doi: 10.1016/j.inffus.2019.12.012.

[2] D. Gunning and D. W. Aha, “DARPA’s Explainable Artificial Intelligence Program,” 2019, doi: 10.1609/aimag.v40i2.2850.

[3] J. Barney, “Firm Resources and Sustained Competitive Advantage,” *J. Manag.*, vol. 17, no. 1, pp. 99–120, Mar. 1991, doi: 10.1177/014920639101700108.

[4] A. Clark and D. Chalmers, “The Extended Mind,” *Analysis*, vol. 58, no. 1, pp. 7–19, 1998.

[5] D. A. Norman, “Design principles for cognitive artifacts,” *Res. Eng. Des.*, vol. 4, no. 1, pp. 43–50, Mar. 1992, doi: 10.1007/BF02032391.

[6] D. Kahneman, *Thinking, fast and slow*, First paperback edition. in Psychology/economics. New York: Farrar, Straus and Giroux, 2013.

[7] M. I. Posner and S. E. Petersen, “The Attention System of the Human Brain,” *Annu. Rev. Neurosci.*, vol. 13, no. Volume 13, 1990, pp. 25–42, Mar. 1990, doi: 10.1146/annurev.ne.13.030190.000325.

[8] J. Sweller, “Cognitive load during problem solving: Effects on learning,” *Cogn. Sci.*, vol. 12, no. 2, pp. 257–285, Apr. 1988, doi: 10.1016/0364-0213(88)90023-7.

[9] G. Hofstede, G. J. Hofstede, and M. Minkov, *Cultures and organizations: software of the mind: intercultural cooperation and its importance for survival*, Revised and Expanded third edition. New York: McGraw-Hill, 2010.

[10] R. J. House, P. J. Hanges, J. Mansour, W. D. Peter, and G. Vipin, *Culture, leadership, and organizations: the GLOBE study of 62 societies*. Thousand Oaks, Calif: Sage Publications, 2004.

[11] S. H. Schwartz, “A Theory of Cultural Values and Some Implications for Work,” *Appl. Psychol.*, vol. 48, no. 1, pp. 23–47, 1999, doi: 10.1111/j.1464-0597.1999.tb00047.x.

Ulysseus R&I Conference 2025
Navigating Pathways:Digital Transformation of Industry
20 October 2025, Košice, Slovak Republic

UlysseusTeachers as Co-Creators of Pedagogical Innovation

Irma Kunnari

School of Professional Teacher Education

Haaga-Helia University of Applied Sciences
Helsinki, Finland

irma.kunnari@haaga-helia.fi

https://orcid.org/0009-0007-8158-3306

***Abstract*— Ulysseus European University positions teachers as active co-creators of pedagogical innovation within transforming higher education landscape. By engaging in collaborative design and experimentation, teachers contribute to the development of student-centred, competence-based, and authentic learning environments. The Ulysseus pedagogical ecosystem and guidelines provide a shared framework that empowers teachers to embrace evolving roles, strengthen inclusivity, and co-create transnational educational practices. Anchored in European values, the model highlights co-creation, digital transformation, and authentic learning as key pillars for sustainable and future-oriented higher education.**

Keywords*— *Pedagogical Innovation, Co-creation, Teacher Development

I. Introduction

In today's rapidly evolving digital landscape, Ulysseus European University is committed to empowering learners and educators through transformative, future-oriented pedagogical practices. This paper explores how Ulysseus fosters digital innovation in higher education by positioning teachers as co-creators of pedagogical transformation within a dynamic, international ecosystem.

Ulysseus offers educators from its partner institutions a unique opportunity to collaboratively design and experiment with innovative, digitally enriched teaching methods. Teachers are encouraged to reflect on their evolving roles—not merely as knowledge transmitters, but as facilitators of active learning, learning designers, and collaborative innovators. This shift supports the creation of student-centred, competence-based, and authentic learning environments that respond to the demands of a globalised and technologically advanced society.

The Ulysseus ecosystem provides a robust support structure for this transformation, offering access to international networks, professional development opportunities, and shared best practices. Teachers are invited to join from their unique starting points, contributing their expertise while learning with and from colleagues across institutions. This collaborative approach fosters a strong sense of belonging and inspires more engaging learning experiences for both students and educators.

Key concepts such as digital bravery and an entrepreneurial mindset are central to this pedagogical evolution. Digital bravery encourages educators to experiment with emerging technologies, even without full mastery, while the entrepreneurial mindset promotes curiosity, co-creation, and iterative innovation. These qualities empower teachers to design adaptive, relevant, and inclusive learning experiences.

This paper will share some examples from the Ulysseus pedagogical guidelines, offering a replicable model for universities aiming to drive digital transformation through empowered, innovative teaching communities.

II. Ulysseus pedagogical guidelines for pegagogical innovation

Co-creation as a working method plays a crucial role in the development of international higher education. It not only strengthens outcomes but also promotes inclusivity and empowers diverse stakeholders to contribute meaningfully to pedagogical innovation [1]. Within the Ulysseus Alliance, co-creation is positioned at the core of building a shared pedagogical ecosystem. Accordingly, the Ulysseus pedagogical guidelines were developed through a co-creation process led by the Ulysseus Pedagogical Development steering group. At the same time, the guidelines are designed to be a living resource, enabling Ulysseus teachers to engage in their own co-creation processes when designing and implementing joint educational activities across partner institutions.

The pedagogical guidelines consist of three distinct sections, which are interconnected and complement each other

- Section 1- *Co-creating Innovative Pedagogy in Ulysseus* introduces the evolving roles of Ulysseus teachers as co-creators of innovative pedagogy and how the Ulysseus Ecosystem can support this development

- Section 2- *Key Pedagogical Elements and Approaches* describes the main pedagogical principles and their practical implications for Ulysseus teachers.
- Section 3 -*Guiding Questions and Tools for Learning Design* provides guiding questions and tools to support Ulysseus teachers in the learning design process

Key pedagogical elements and approaches in the Section 2 are based on four following pillars.

Student-Centredness -*Empowering Learners in Inclusive Environment*, is a cornerstone of Ulysseus pedagogy, and it empowers learners to become architects of their own learning, fostering autonomy, ownership, creativity, and critical thinking. Teachers act as facilitators, cultivating inclusive environments where students thrive through hands-on experiences, collaboration, and real-world problem-solving. Learning becomes meaningful when connected to personal and real-world contexts, while engagement and inspiration grow through active participation. In Ulysseus' diverse international context, inclusivity is essential—students must feel heard, respected, and safe. Teachers support this by addressing language barriers, encouraging dialogue, and designing collaborative structures. Through guidance and inclusive strategies, they help students connect across differences and build a shared learning community. Student-centred learning equips students with the skills, confidence, and mindset to solve real-world problems and adapt to change.

Competence-Based Approach –*Leaning on Constructive Alignment* Competence-based higher education focuses on students' ability to apply knowledge, skills, and attitudes in real-world contexts. It integrates theory with practice to prepare graduates for future societal and labour market needs [2,3]. This approach promotes future-proof competences—such as critical thinking, creativity, collaboration, and resilience—alongside student agency and well-being [4]. Constructive alignment ensures coherence between learning outcomes, activities, and assessment, supporting high-quality education [5].

Authentic learning – Solving inspiring real-world challenges Authentic learning is central, engaging students in meaningful, real-life challenges that foster critical thinking, collaboration, and innovation. These settings also support teachers' professional development. Designed with societal and industry partners, Ulysseus Innovation Hubs enable transnational, interdisciplinary collaboration and co-creation of solutions to real-world problems.

In these environments, various innovative and entrepreneurial pedagogical approaches—such as work-based, research-based, and challenge-based learning—integrate research, development, and innovation (RDI) into students' learning. These methods combine theory and practice, promote active student participation, and enhance employability through future-proof competences. Teachers act as facilitators, guiding students through complex, authentic learning experiences.

Digital Transformation – *Enhancing and Enriching Learning* Digitalisation and GenAI are transforming higher education. Teachers support students in developing critical and responsible AI skills, helping them acquire future-proof competences. At Ulysseus, GenAI is integrated into student-centred and competence-based learning, encouraging ethical exploration of emerging technologies. UNESCO's AI competency frameworks [6,7] stress human-centred and ethical use of AI in education. As GenAI becomes more accessible, it enhances learning and inclusivity, but also raises questions about human agency [8].

III. Conclusion

In a rapidly changing world that demands new and innovative pedagogical approaches, Ulysseus does not expect every teacher to master all practices or roles at once. Instead, it fosters a continuous journey of professional growth, where collective strength arises from shared expertise, mutual learning, and collaboration. Through this co-creation model, Ulysseus not only drives pedagogical innovation but also nurtures dynamic innovation ecosystems and reinforces partnerships across academia, industry, and society. In doing so, it offers a sustainable pathway for higher education to remain responsive, inclusive, and future-oriented.

References

[1] Omland, M., Hontvedt, M., Siddiq, F., Amundrud, A., Hermansen, H., Mathisen, M. A. S., Rudningen, G., & Reiersen, F. (2025). *Co-creation in higher education: A conceptual systematic review*. Higher Education. https://doi.org/10.1007/s10734-024-01364-1

[2] European Commission. (2023). *European Education Area: Competence frameworks*. https://education.ec.europa.eu

[3] The Future of Jobs Report. World Economic Forum. The Future of Jobs Report 2025 | World Economic Forum

[4] OECD. (2023). *OECD Learning Compass 2030*. https://www.oecd.org/education/2030-project/

[5] Biggs, J., Tang, C., & Oon, P. T. (2022). *Teaching for quality learning at university* (5th ed.). Open University Press.

[6] UNESCO. (2024). *AI competency framework for teachers*. https://unesdoc.unesco.org/ark:/48223/pf0000391104

[7] UNESCO. (2024). *AI competency framework for students*. https://www.unesco.org/en/articles/what-you-need-know-about-unescos-new-ai-competency-frameworks-students-and-teachers

[8] European Parliament. (2024). *Artificial Intelligence Act: Regulation (EU) 2024/1689*. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32024R1689

Ulysseus R&I Conference 2025
Navigating Pathways:Digital Transformation of Industry
20 October 2025, Košice, Slovak Republic

The Ulysseus Pedagogical Framework for Sustainable Digital Education

Djibril Dieng
International Department
Université Côte d'Azur
Nice, France
https://orcid.org/0000-0003-0179-0377

Lyuba Stafyeyeva
The Entrepreneurial School
MCI
Innsbruck, Austria
https://orcid.org/0000-0002-3402-1358

Kirsi Korkealehto
School of Professional Teacher Education
Haaga-Helia University of Applied Sciences
Helsinki, Finland
https://orcid.org/0000-0001-8596-384X

***Abstract*— The Ulysseus Pedagogical Guidelines, co-created by eight European universities in the Ulysseus Alliance, offer a forward-looking framework for aligning higher education with the demands of digital transformation. Grounded in practice, the guidelines support educators in designing inclusive, competence-based, and sustainability-driven learning environments. They rest on four interrelated pillars: student-centeredness, constructive alignment, authentic real-world problem-solving, and ethical digital transformation. Central to the model is the concept of digital bravery, which encourages responsible integration of emerging technologies, such as Generative AI, while upholding inclusivity, critical thinking, and ethical standards. By reframing the role of teachers as facilitators, designers, and co-creators of knowledge, the guidelines provide a structured approach to innovation-oriented pedagogy. Early implementation across the alliance has demonstrated the potential of this framework through initiatives such as Collaborative Online International Learning (COIL), which enhance student engagement, digital fluency, and cross-border collaboration.**

Keywords*— *Digital pedagogy, sustainable education, AI in teaching, educational innovation

I. Introduction

In the era of rapid technological change, higher education must prepare graduates for real-world innovation. Yet, innovation remains fragmented, and many teachers face challenges in adopting new pedagogical practices. Given the uncoordinated nature of innovation and the varying levels of teacher preparedness, the *Ulysseus Pedagogical Guidelines* bridge this gap. It is a forward-thinking framework co-created by eight European universities forming the Ulysseus University Alliance. These guidelines positions universities as catalysts for the digital transformation of education.

II. Four Foundational Pillars

The guidelines are built around four interrelated pillars:

Student-centredness – fostering inclusive environments where learners actively construct knowledge, develop agency, and collaborate across differences.

Competence-based approach– ensuring constructive alignment between outcomes, activities, and assessment to develop future-proof competences such as creativity, resilience, and collaboration. It emphasises the integration of theoretical knowledge with practical skills, preparing graduates for the demands of the future job market and society [1, 2].

Authentic learning – engaging students in solving real-world challenges in collaboration with industry and societal partners, through challenge-based, research-based, and work-based approaches.

Digital transformation – encouraging 'digital bravery', where teachers responsibly explore technologies like Generative AI and VR to enrich learning while embedding ethics and inclusivity. Ulysseus is committed to nurturing a digital culture that encourages proactive readiness for change and the effective adoption and utilisation of new technologies into learning. The European Digital Comptence Framework for Educators (DigiCompEdu) [3] highlights digital skills that teachers need to possess to adapt to digitalisation and support the development of students' digital competences. Ulysseus' digital culture aligns with the EU directives on digital culture in the 2030 Digital Compass [4] as well as the Digital Culture Guidebook [5] and the DigCompEdu [3].

These four pillars reflect an evolving teacher role: from transmitters of knowledge to facilitators, learning designers, and collaborative innovators.

III. The Nine-Phase Learning Design Process

Our nine-phase learning design process is a structured and replicable approach that helps educators build and continuously refine digitally aligned courses. Below is a summary of the nine-phase design process from the Ulysseus Pedagogical Guidelines.

The course preparation starts by identifying the necessary resources, establishing timelines, and familiarising themselves with institutional practices. This foundational step ensures that the planning process is grounded and aligned with the broader educational context. Next, the teachers focus on building connections with partners and collaborators. This involves clarifying expectations, defining roles and responsibilities, and fostering a spirit of teamwork that supports the course's development and delivery.

With a strong foundation in place, the teachers then articulate the vision for the course. This includes determining the type of course, such as Collaborative Online International Learning (COIL) or Blended Intensive Program (BIP), identifying the target learner groups, specifying the intended learning outcomes, and considering the involvement of relevant stakeholders. Thereafter, the teachers proceed to design the structure of the course by outlining its architecture, organising content into logical units, and ensuring that each component aligns with the desired outcomes. This structural clarity supports both teaching and learning.

To promote meaningful learning experiences, the teachers emphasise engagement by ensuring constructive alignment between learning outcomes, activities, and assessments. They design varied and collaborative tasks that encourage active participation and deeper understanding. Further, developing content is another key step, where the teachers create high-quality learning materials that are inclusive and accessible. These materials are designed to support the diverse needs of all learners and foster an equitable learning environment.

Throughout the course, collaboration remains essential. The teachers establish effective communication and teamwork practices, both among teaching staff and with students, to maintain a supportive and interactive learning community. As the course unfolds, the teachers implement evaluation strategies, including formative and summative assessments, feedback mechanisms, and opportunities for self- and peer-assessment. These practices help monitor progress and guide improvements. Finally, the teachers engage in refinement by collecting feedback from students and colleagues, reflecting on the outcomes, and using these insights to enhance the course for future iterations. This continuous improvement cycle ensures that the course remains relevant, effective, and responsive to learners' needs.

Early implementation across the Ulysseus Alliance has resulted in several Collaborative Online International Learning (COIL) experiences, enhancing student engagement and digital fluency across Europe. **COIL courses** have fostered intercultural collaboration and digital fluency, and **Blended Intensive Programmes (BIPs)** have engaged students in cross-border challenge-based learning.

IV. Conclusion

These pedagogical guidelines have been developed to support both current and prospective educators within the Ulysseus alliance. While they do not encompass the entirety of pedagogical methodologies nor prescribe rigid instructional frameworks, they are intended to serve as a guiding framework; orienting educators toward innovative, collaborative, and future-oriented teaching practices. Their purpose is to empower Ulysseus educators to actively contribute to the transformation of higher education.

The professional journey of Ulysseus educators is characterised by continuous learning, reflection, and pedagogical evolution. By engaging with these guidelines and integrating them into their teaching practices, educators play a pivotal role in shaping future learning environments, fostering intellectual curiosity, and nurturing critical and compassionate learners. The collective commitment of Ulysseus educators generates a dynamic synergy that enhances the quality and impact of teaching across the alliance.

The guidelines are intended to facilitate shared reflection, promote collaborative thinking, and encourage the exchange of ideas among peers. Hopefully, teachers will find inspiration within these principles to develop and refine innovative teaching strategies. Moreover, these guidelines contribute to the development of the Ulysseus pedagogical ecosystem, a collaborative and evolving space dedicated to the co-creation of sustainable and impactful educational practices. This collective endeavour is essential for ensuring the continued relevance and quality of higher education, and for equipping students with the skills necessary to thrive in an increasingly complex and interconnected world.

Educators are encouraged to interpret and apply these principles in ways that align with their individual teaching contexts, while also actively participating in the shared pursuit of pedagogical excellence across the Ulysseus community.

References

[1] European Skills Agenda. European Commission. European Skills Agenda - European Commission

[2] The Future of Jobs Report. World Economic Forum. The Future of Jobs Report 2025 | World Economic Forum

[3] The European Digital Competence Framework for Educators (DigiCompEdu) European Commission. The European Digital Competence Framework for Educators (DigCompEdu).

[4] Europe’s Digital Decade: digital targets for 2030 – Documents. European Commission. Europe’s Digital Decade: digital targets for 2030 - Documents - European Commission

[5] Digital Culture: The Driving Force of Digital Transformation. World Economic Forum. WEF_Digital_Culture_Guidebook_2021.pdf

Ulysseus R&I Conference 2025
Navigating Pathways:Digital Transformation of Industry
20 October 2025, Košice, Slovak Republic

Relational Cognitive Ecologies in Higher Education: A Systemic View on AI Transformation at the University of Genoa

Flavio Tonelli
DIME - Department of Mechanical, Energy, Management and Transportation Engineering, University of Genoa, Italy
Flavio.Tonelli@unige.it

Antonio Giovannetti
DIME - Department of Mechanical, Energy, Management and Transportation Engineering, University of Genoa, Italy
antonio.giovannetti@edu.unige.it

***Abstract*—This paper explores the University of Genoa's strategic response to the integration of artificial intelligence (AI) in higher education, emphasizing a shift from fragmented, tool-based adoption to a relational, systemic approach grounded in co-evolutionary pedagogical methodologies. Drawing on the recent internal initiatives and ongoing collaborations with industry and public partners, we examine how generative AI is impacting all phases of academic teaching and learning. We introduce the concept of relational cognitive ecologies as a foundational paradigm to support intentional, ethically grounded, and pedagogically meaningful AI integration. Through methodological reconfigurations that prioritize adaptive learning architectures, dialogical presence, and metacognitive transparency, we propose a framework for universities to become transformative agents in the digital education landscape while maintaining cognitive sovereignty and human agency.**

Keywords—*Artificial Intelligence, Higher Education, Cognitive Ecologies, Pedagogical Innovation, Digital Transformation, Co-evolutionary Learning, Ethics*

I. INTRODUCTION

As digital transformation reshapes the higher education landscape, universities across Europe are called upon not merely to adopt emerging technologies, but to interrogate their epistemic, ethical, and pedagogical implications (Selwyn, 2019; Zawacki-Richter et al., 2019). The University of Genoa, as part of the Ulysseus European University alliance, is confronting this challenge by fundamentally rethinking the integration of AI within its institutional framework. Our central thesis is that AI in education must be approached not as a modular technological upgrade but as a shift in the ecology of cognition itself, requiring systemic coordination, relational awareness, and what we term cognitive sovereignty (Birhane, 2021).

The rapid proliferation of generative AI technologies has created what Luckin et al. (2016) describe as an "intelligence paradox" in education: while these systems demonstrate remarkable capabilities in content generation and analysis, their integration often diminishes rather than enhances human cognitive agency. This paradox emerges from what we identify as a fundamental misunderstanding of AI's role in educational contexts—treating it as a sophisticated tool rather than as a relational presence that co-shapes the learning environment (Bayne, 2015).

This paper presents the University of Genoa's strategic response to this challenge through the development of relational cognitive ecologies—pedagogical environments where human and artificial intelligences co-evolve through intentional, ethically grounded interactions. We argue that such ecologies require not just technological infrastructure but methodological reconfigurations that fundamentally alter how we conceive teaching, learning, and assessment in the digital age.

II. FROM FRAGMENTATION TO SYSTEMIC TRANSFORMATION

A. The Current Landscape of AI Adoption in Higher Education

Historically, AI adoption at UniGe, as in many European universities, has been characterized by department-level experimentation, often disconnected and opportunistic (European Commission, 2021). This fragmented approach reflects what Selwyn et al. (2020) identify as the "solutionist fallacy"—the assumption that complex educational challenges can be addressed through discrete technological interventions.

Recent surveys of European higher education institutions reveal that while lot of these institutions have experimented with AI technologies, only few have developed coherent institutional strategies for their integration (Crompton & Burke, 2023). This disconnect between adoption and strategy has resulted in what we term "performative innovation"—surface-level implementations that satisfy institutional pressure for digital transformation without addressing deeper questions of pedagogical purpose and ethical responsibility.

B. The Unige Initiative: Toward Systemic Coordination

The launch of the "AI in Education" initiative at UniGe marks a deliberate attempt to shift from episodic implementations to a unified, future-oriented strategy. This transition is driven by the recognition that without substantial financial investment, organizational commitment, and interdisciplinary collaboration, universities risk presenting a shallow engagement with AI that ultimately undermines their credibility and capacity for innovation.

The initiative encompasses three strategic pillars:

1. **Infrastructure Development**: Creation of hybrid physical-digital learning environments equipped with AI-enhanced pedagogical tools
2. **Faculty Development**: Comprehensive training programs that move beyond technical skills to include ethical reasoning and relational competencies
3. **Research Integration**: Alignment of AI research activities with pedagogical innovation, creating feedback loops between discovery and teaching

This systemic approach reflects what Gašević et al. (2023) describe as "institutional AI literacy"—the collective capacity of an organization to understand, evaluate, and ethically deploy AI technologies in service of its core mission.

III. GENERATIVE AI'S TRANSFORMATIVE IMPACT ACROSS EDUCATIONAL PHASES

A. *Curriculum Design and Content Creation*

Generative AI technologies are fundamentally altering curriculum design processes, enabling what we term "dynamic curricular architectures" (Chen et al., 2022). At UniGe, pilot programs in engineering and digital humanities have demonstrated how AI can support:

- **Co-creative syllabus development**: AI systems analyze emerging research trends, industry demands, and student feedback to suggest curricular modifications in real-time
- **Adaptive content generation**: Creation of learning materials that respond to individual student progress and learning styles
- **Interdisciplinary synthesis**: AI-assisted identification of connections between traditionally separate fields, fostering innovative course designs

However, this transformation raises critical questions about curricular authority and the role of human expertise in educational design (Williamson, 2023). Our approach emphasizes what we call "augmented expertise"—AI as amplifier of human pedagogical wisdom rather than its replacement.

B. Teaching Delivery and Multimodal Interaction

The integration of AI in teaching delivery has moved beyond simple automation toward sophisticated forms of pedagogical partnership (Holstein et al., 2019). At UniGe, experimental implementations include:

- **Dialogical teaching assistants**: AI systems capable of sustained, contextually appropriate interactions with students
- **Real-time concept mediation**: AI analysis of student responses to adjust explanatory strategies dynamically
- **Multimodal content adaptation**: Automatic generation of visual, auditory, and textual representations of complex concepts

These innovations require what we term "pedagogical presence"—the capacity to maintain authentic human connection within technologically mediated environments (Garrison et al., 2000, extended for AI contexts).

C. Assessment Revolution and Cognitive Tracing

Perhaps nowhere is AI's impact more profound than in assessment practices. Traditional evaluation methods become inadequate when students have access to AI systems capable of sophisticated text generation and problem-solving (Newton & Shaw, 2023). UniGe is developing:

- **Process-focused assessment**: Evaluation of learning trajectories rather than just outcomes
- **Metacognitive transparency protocols**: Methods for making student thinking visible during AI-assisted work
- **Collaborative evaluation frameworks**: Assessment of human-AI partnership quality rather than individual performance alone

D. Intelligent Tutoring and Personalized Support

The deployment of AI tutoring systems at UniGe goes beyond traditional adaptive learning platforms to embrace what we call "relational tutoring"—AI systems that develop ongoing relationships with learners. Key features include:

- **Emotional sensitivity**: Recognition and appropriate response to student emotional states
- **Learning partnership**: AI systems that learn about individual students' preferences, strengths, and challenges over time

- **Ethical guidance**: Built-in capacity to raise ethical questions about learning choices and academic integrity

IV. Methodological Reconfigurations: Toward Adaptive Pedagogical Architectures

A. Co-evolutionary Learning Design

Traditional instructional design models, based on predetermined learning objectives and linear progression, prove inadequate for AI-enhanced environments (Mor & Winters, 2007). We propose co-evolutionary learning design—pedagogical architectures that adapt based on emergent interactions between students, faculty, and AI systems.

This approach involves:

Dynamic Learning Trajectories: Rather than fixed curricula, we develop learning pathways that evolve based on student discoveries, AI insights, and faculty observations. This requires sophisticated tracking systems that capture not just learning outcomes but learning processes and their evolution over time.

Emergent Competency Recognition: Traditional competency frameworks assume predictable skill development. Co-evolutionary design recognizes that human-AI collaboration may generate entirely new forms of competency that cannot be predetermined. Assessment systems must be capable of recognizing and validating these emergent capabilities.

Adaptive Assessment Ecologies: Moving beyond standardized testing toward assessment environments that adjust their evaluation criteria based on the learning context and the nature of human-AI collaboration observed.

B. Dialogical Presence in Hybrid Environments

The challenge of maintaining authentic human connection in AI-mediated learning environments requires what we term "dialogical presence"—the capacity to create spaces for genuine encounter despite technological mediation

Key methodological innovations include:

Presence Protocols: Systematic approaches for faculty to maintain awareness of their relational impact in AI-enhanced classrooms. This includes techniques for recognizing when AI mediation enhances versus diminishes authentic connection with students.

Threshold Facilitation: Training faculty to serve as "guardians of thresholds"—recognizing moments when students are transitioning between different ways of understanding or relating to material, and knowing when to intervene directly versus allowing AI systems to provide support.

Collective Intelligence Cultivation: Methods for fostering what emerges when human and artificial intelligences genuinely collaborate rather than simply coexist. This requires attention to group dynamics, timing, and the quality of questions that open rather than close exploratory spaces.

C. Metacognitive Transparency and Cognitive Sovereignty

- Perhaps most critically, AI integration in education must cultivate rather than diminish students' awareness of their own thinking processes (Flavell, 1979, extended for AI contexts). We develop:

- **Cognitive Sovereignty Practices**: Methodologies that help students maintain agency in their relationship with AI systems. This includes recognizing when AI assistance enhances versus substitutes for their own thinking, and developing criteria for making these distinctions.

- **Thinking-Partnership Protocols**: Structured approaches for students to reflect on and articulate their collaboration with AI systems. Students learn to identify what they contribute to the partnership, what the AI contributes, and what emerges that neither could produce alone.

- **Ethical Reflection Integration**: Regular practices that help students examine the implications of their AI-assisted work—not just for academic integrity but for their development as critical thinkers and responsible citizens.

V. Strategic Implementation Framework

A. *Institutional Infrastructure Development*

To support these methodological reconfigurations, UniGe is establishing:

AI Pedagogical Innovation Lab: A dedicated space for faculty experimentation with AI-enhanced teaching methods, including both technological infrastructure and ongoing research on pedagogical effectiveness.

Cognitive Sovereignty Center: An interdisciplinary research center focused on understanding and supporting human agency in AI-mediated environments, with particular attention to educational contexts.

Ethical AI Governance Council: A body including faculty, students, AI researchers, and external experts, responsible for ongoing evaluation of AI integration's impact on institutional values and educational mission.

B. Faculty Development and Support

The transition to relational cognitive ecologies requires comprehensive faculty development that goes far beyond technical training:

Relational Competency Development: Training focused on recognizing and cultivating authentic human connection within technologically mediated environments.

AI Partnership Skills: Not just how to use AI tools, but how to develop productive working relationships with AI systems that enhance rather than diminish pedagogical effectiveness.

Ethical Reasoning in Practice: Ongoing development of faculty capacity to recognize and address ethical dimensions of AI integration as they emerge in real classroom situations.

C. Collaboration Networks

UniGe's transformation occurs within broader collaborative networks:

Industry Partnerships: Collaboration with organizations like START4.0 and involvement in projects like SafeGPTIoT ensure that educational innovation remains connected to emerging professional realities while maintaining academic integrity.

Ulysseus Alliance Integration: Sharing methodological innovations across the alliance network, creating opportunities for comparative research and mutual learning.

International Research Networks: Participation in global research initiatives examining AI's impact on higher education, contributing local innovations to broader understanding.

VI. Ethical Dimensions and Governance Challenges

A. Beyond Compliance: Toward Ethical Innovation

While compliance with regulatory frameworks (AI Act, GDPR) provides necessary guardrails, truly ethical AI integration requires what we term "anticipatory ethics"—considering not just current regulations but the broader implications of our choices for human flourishing (Jonas, 1984, applied to AI contexts).

Key ethical considerations include:

Cognitive Justice: Ensuring that AI integration doesn't inadvertently disadvantage students who learn differently or come from different cultural backgrounds. This requires ongoing attention to how AI systems encode particular ways of thinking and being.

Human Agency Preservation: Vigilance against what Coeckelbergh (2020) terms "moral deskilling"—the gradual erosion of human capacity for ethical reasoning and decision-making through over-reliance on AI systems.

Transparency and Explainability: Not just technical explainability, but the capacity for all participants in educational environments to understand how AI systems are influencing learning processes and outcomes.

B. Democratic Participation in AI Integration Meaningful AI integration requires genuine participation from all stakeholders, not just technical experts and administrators:

Student Voice Integration: Systematic inclusion of student perspectives not just in evaluation of AI systems but in their design and implementation.

Faculty Agency: Ensuring that faculty retain meaningful control over their pedagogical practices even as these are enhanced by AI systems.

Community Engagement: Recognition that university AI practices have implications beyond institutional boundaries, requiring ongoing dialogue with broader communities.

VII. Research Agenda and Future Directions

A. Empirical Research Priorities

The development of relational cognitive ecologies requires sustained empirical investigation:

Learning Process Documentation: Longitudinal studies of how student learning processes evolve in AI-enhanced environments, with particular attention to metacognitive development.

Faculty Adaptation Research: Understanding how faculty pedagogical practices change over time through AI integration, identifying factors that support versus hinder meaningful adaptation.

Institutional Culture Studies: Examining how AI integration affects broader institutional culture, including values, power relationships, and decision-making processes.

B. Methodological Innovation Needs

Assessment Method Development: Creating evaluation approaches adequate to the complexity of human-AI collaborative learning.

Ethical Framework Refinement: Ongoing development of ethical frameworks that can guide decision-making in rapidly evolving technological contexts.

Scaling Strategy Research: Understanding how successful innovations in AI-enhanced education can be adapted across different institutional contexts without losing their essential qualities.

VIII. Conclusion and Forward Outlook

The integration of AI in higher education represents not merely a technological shift but an opportunity for institutional metamorphosis. The University of Genoa's approach, grounded in relational cognitive ecologies and methodological innovation, demonstrates that universities can position themselves as active co-designers of educational futures rather than passive adopters of external technologies.

Our experience suggests three critical success factors for meaningful AI integration in higher education:

1. **Relational Awareness**: Recognition that AI systems are not neutral tools but relational presences that shape the quality of educational interactions
2. **Methodological Courage**: Willingness to fundamentally reconfigure pedagogical practices rather than simply augmenting existing approaches with AI capabilities
3. **Ethical Commitment**: Sustained attention to how AI integration serves or undermines core educational values, with particular attention to human agency and democratic participation

As we move forward, we call for the establishment of a Ulysseus-wide Observatory on AI and Education to monitor, reflect upon, and guide systemic transitions across the alliance. Such an observatory would ensure that European universities remain at the forefront of relational, ethically grounded digital transformation while contributing to global understanding of AI's role in human development. The future of higher education lies not in choosing between human and artificial intelligence, but in learning to cultivate their productive partnership. This requires not just technological sophistication but wisdom—the kind of practical judgment that emerges from sustained reflection on what it means to educate human beings in an age of artificial minds.

REFERENCES

[1] Bayne, S. (2015). What's the matter with 'technology-enhanced learning'? *Learning, Media and Technology*, 40(1), 5-20.

[2] Birhane, A. (2021). Algorithmic injustice: A relational ethics approach. *Patterns*, 2(2), 100205.

[3] Chen, L., Chen, P., & Lin, Z. (2022). Artificial intelligence in education: A review. *IEEE Access*, 8, 75264-75278.

[4] Coeckelbergh, M. (2020). *AI Ethics*. MIT Press.

[5] European Commission. (2021). *Digital Education Action Plan 2021-2027*. Publications Office of the European Union.

[6] Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry. *American Psychologist*, 34(10), 906-911.

[7] Garrison, D. R., Anderson, T., & Archer, W. (2000). Critical inquiry in a text-based environment: Computer conferencing in higher education. *The Internet and Higher Education*, 2(2-3), 87-105.

[8] Gašević, D., Siemens, G., & Sadiq, S. (2023). Empowering learners for the age of artificial intelligence. *Computers and Education: Artificial Intelligence*, 4, 100130.

[9] Holstein, K., McLaren, B. M., & Aleven, V. (2019). Co-designing a real-time classroom orchestration tool to support teacher-AI complementarity. *Journal of Learning Analytics*, 6(2), 27-52.

[10] Crompton, H., & Burke, D. (2023). Artificial intelligence in higher education: the state of the field. *International journal of educational technology in higher education*, *20*(1), 22.

[11] Jonas, H. (1984). The Imperative of Responsibility: In Search of an Ethics for the Technological Age. University of Chicago Press.

[12] Luckin, R., Holmes, W., Griffiths, M., & Forcier, L. B. (2016). *Intelligence Unleashed: An Argument for AI in Education*. Pearson.

[13] Mor, Y., & Winters, N. (2007). Design approaches in technology-enhanced learning. *Interactive Learning Environments*, 15(1), 61-75.

[14] Nye, B. D. (2015). Intelligent tutoring systems by and for the developing world: A review of trends and approaches for educational technology in a global context. *International Journal of Artificial Intelligence in Education*, 25(2), 177-203.

[15] Selwyn, N. (2019). What's the problem with learning analytics? *Journal of Learning Analytics*, 6(3), 11-19.

[16] Selwyn, N., Hillman, T., Eynon, R., Ferreira, G., Knox, J., Macgilchrist, F., & Sancho-Gil, J. M. (2020). What's next for Ed-Tech? Critical hopes and concerns for the 2020s. *Learning, Media and Technology*, 45(1), 1-6.

[17] Williamson, B. (2023). Digital Education Governance: Data Visualization, Predictive Analytics, and 'Real-time' Policy Instruments. Journal of Education Policy, 38(1), 132-148.

[18] Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education–where are the educators? *International Journal of Educational Technology in Higher Education*, 16(1), 1-27.

.

Ulysseus R&I Conference 2025
Navigating Pathways:Digital Transformation of Industry
20 October 2025, Košice, Slovak Republic

Spectrum of Artificial Intelligence in Mineral Exploration

Anastasia Enderova
Institute of Geoscience
FBERG
Technical University Kosice
Slovakia
anastasiia.enderova@tuke.sk

Juraj Janocko
Institute of Geoscience
FBERG
Technical University Kosice
Slovakia
juraj.janocko@tuke.sk

Jan Genci
Department od Computers and Informatics, FEI
Technical University Kosice
Slovakia
jan.genci@tuke.sk

***Abstract*—The integration of Artificial Intelligence (AI) in mineral exploration is transforming the industry by enhancing the efficiency, precision, and sustainability of exploration processes. This paper explores how AI technologies are used to analyze vast and diverse datasets through machine learning algorithms. This paper provides an overview of AI's role in modern mineral exploration, showcasing innovative applications through real-world examples from companies such as Minerva, GoldSpot, Datarock, and KoBold Metals.**

Keywords — Artificial Intelligence, Mineral Exploration, Machine Learning, Geological Data Analysis, Predictive Modeling

I. INTRODUCTION

Artificial Intelligence (AI) is transforming mineral exploration by enabling faster, more accurate analysis of complex geological data. Through machine learning, AI can detect patterns in geophysical, geochemical, and remote sensing datasets, significantly improving the efficiency and success rate of discovering mineral deposits. This paper explores key AI applications in the industry, with real-world examples from companies like Minerva, GoldSpot, Datarock, and KoBold Metals.

II. METHODS & DATA

AI exploration technologies operate by combining vast datasets from various sources, including:

- Geophysical Data: Magnetic, seismic, and gravity surveys.
- Geochemical Data: Soil, rock, and water sample analyses.
- Remote Sensing: Satellite imagery and aerial photography.

Machine learning algorithms process this data to identify patterns and correlations indicative of mineralisation. For example, AI can detect geochemical anomalies or structural features associated with ore deposits.

This technology offers significant potential for improving the accuracy, speed, and sustainability of mineral exploration, addressing both economic and environmental challenges. By reducing costs and increasing discovery rates, AI is becoming an essential tool in the industry, guiding more informed decision-making and enhancing exploration outcomes

Machine learning data analysis methodologies are revolutionising how mineral deposits are identified. By integrating advanced 3D subsurface imaging techniques, AI can reduce exploration costs by up to 30% while increasing discovery rates by 20%.

The integration of AI not only offers unprecedented opportunities for more efficient, precise, and sustainable exploration but also ensures that the industry remains responsive to global economic and environmental challenges.

III. APPLICATION IN MINERAL EXPLORATION

1. Minerva TERRA AI Minerva's AI platform is using human-generated knowledge models and probabilistic reasoning to generate predictive analyses. This is accomplished by using semantic networks to store information for their computer reasoning. Semantic networks represent logical relations between concepts in data and allow cognitive AI to closely replicate how a human would think about subjects. Using semantic networks as its primary data format means Minerva's software is specifically engineered to represent conceptual knowledge and not just unique traits in a dataset. 2. GoldSpot Discoveries GoldSpot Discoveries Corp. specializes in the mineral exploration industry and uses data-driven science, artificial intelligence, and machine learning for gold target generation in Canada. The Applied Geophysics team at GoldSpot focuses on the acquisition of airborne geophysical data with the use of their Multi-Parameter Acquisition Survey System (MPASS), which is a helicopter-bourne system capable of collecting magnetic, magnetic gradiometry, very-low-frequency electromagnetic (VLF-EM), radiometric and LiDAR data. 3. Datarock

Application Datarock application uses deep learning to automatically classify lithology, alteration, and structures from drill core photographs. Helps exploration teams speed up core logging and reduce subjectivity. 4. KoBold Metals KoBold builds hybrid AI models for mineral exploration and deploys those models to guide decisions on exploration programs. KoBold Metals combines machine learning, Bayesian models, and geological rules into a hybrid AI system for battery metal (cobalt, nickel, copper) exploration.

III. CONCLUSION

The integration of Artificial Intelligence into mineral exploration marks a transformative shift in the industry, offering greater efficiency, precision, and sustainability. AI technologies, through their ability to analyze and interpret large datasets, have revolutionized mineral exploration by enabling the detection of hidden deposits with higher accuracy and lower cost. The case studies presented—ranging from Minerva's predictive analytics to GoldSpot's geophysical data integration and Datarock's core logging solutions—highlight the diverse ways in which AI is being applied to improve exploration processes. As the technology continues to evolve, it is expected that AI will play an even more significant role in shaping the future of mineral discovery, supporting both economic growth

REFERENCES

[1] Aggarwal, C.C., 2015. An introduction to data mining. In: Aggarwal, C.C. (Ed.), Data Mining: The Textbook. Springer International Publishing, pp. 1–26.

[2] F. Yang at al, 2024, Artificial intelligence for mineral exploration: A review and perspectives on future directions from data science, Earth-Science Reviews 258

[3] K. Bergen et al, 2019. Machine learning for data-driven discovery in solid Earth geoscience, Science 363 eaau0323.

[4] Davies et al, 2025, Artificial Intelligence and Machine Learning to enhance critical mineral deposit discovery, Geosystems and Geoenvironment

[5] Haldar, S.K., 2013. Chapter 1 - Mineral exploration. In: Mineral Exploration. Elsevier,

[6] Boston, pp.

Ulysseus R&I Conference 2025
Navigating Pathways:Digital Transformation of Industry
20 October 2025, Košice, Slovak Republic

Digital Transformation and the Rise of Social Engineering Attacks

Miroslav Murin[1]
[1] Technical university of Košice
Košice, Slovakia
miroslav.murin@tuke.sk

Miroslav Michalko[1]
[1] Technical university of Košice
Košice, Slovakia
miroslav.michalko@tuke.sk

Abstract: The rapid pace of digitalization has transformed modern society, driving innovation and efficiency across industries while simultaneously expanding the surface for cyber threats. Among the most prominent and damaging risks are social engineering attacks—particularly phishing and vishing—which exploit human psychology rather than technical vulnerabilities. This paper examines how digitization amplifies social engineering risks by enabling large-scale, AI-enhanced, and highly personalized attacks that target trust, urgency, and authority. It explores the cognitive and technological mechanisms underlying these threats and emphasizes the growing inadequacy of traditional, perimeter-based security approaches. The study argues that effective cybersecurity in the digital era must integrate human-centric strategies with technical safeguards, focusing on awareness training, behavioral interventions, and secure-by-design principles. By fostering a strong security culture and aligning human and technological defenses, organizations can build resilience against the evolving landscape of socio-technical cyber threats.

Keywords: Digitalization, Social engineering, Phishing, Vishing, Cybersecurity

I. Introduction

Digitization has transformed modern life, boosting innovation and efficiency across all sectors—but it also expands the threat landscape. As organizations adopt cloud platforms, IoT, and AI, attackers increasingly exploit human weaknesses through social engineering, especially phishing (email or web deception) and vishing (voice manipulation). These tactics use psychological triggers like trust or urgency to extract credentials, payments, or access, often enhanced by spoofed domains, generative AI, and deepfake voices.

Consequences include data breaches, financial losses, and reputational harm. Traditional defenses such as perimeter security or static training are no longer sufficient. Modern protection requires integrating human-focused and technical measures: phishing-resistant authentication, least-privilege access, behavioral analytics, and resilient response.

This article explores how digital transformation amplifies social engineering risks and proposes a layered defense combining technology, process, and behavioral strategies to manage human-centric cyber threats in a highly digitized world.

II. Social Engineering

Social engineering represents the psychological manipulation of human behavior to compromise security, exploiting trust, authority, urgency, and fear rather than technical vulnerabilities. This form of attack targets the human element—often considered the weakest link in cybersecurity—by leveraging cognitive biases and emotional triggers that bypass rational decision-making. The attack lifecycle typically follows four distinct phases: reconnaissance to gather target information, establishing trust through personalized communication, exploiting that trust to extract sensitive data, and executing the attack while covering tracks. Unlike traditional hacking methods that exploit software vulnerabilities, social engineering attacks are particularly dangerous because they rely on fundamental human psychology, making them harder to predict and defend against through technical controls alone.

A. Phishing

Phishing is a method of cyber attack that involves sending deceptive messages, usually emails or messages that appear to come from trusted sources. The goal is to trick individuals into revealing sensitive information, such as usernames, passwords, and credit card details, or into installing malicious software on their devices. As the authors claim in [1], phishing is one of the most widespread and harmful cyber threats affecting individuals and organizations around the world. According to the authors in [2], only 25% of the 382 participants tested were able to detect phishing sites from legitimate ones.

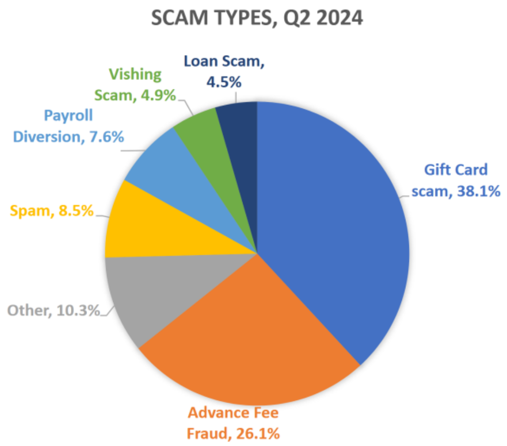

Figure 1 Types of fraud, Q2 2024[3]

The APWG, which publishes regular reports on phishing, stated in its report for the second quarter of 2024[3] that it had identified 877,536 phishing attacks. The trend in attacks has been stable for some time. They also reported that phishing via phone calls and text messages is increasingly being used to attack bank customers and payment service users. Figure 1.3 shows the percentage share of different types of phishing attacks. According to the authors in [4], the threat of pretexting is growing rapidly due to improvements in the quality of generative AI. Thanks to this, fake stories and texts are constantly improving and becoming increasingly difficult to distinguish from the real thing. Organizations cannot ignore digitization, yet each transformation increases vulnerability to social engineering. As many have already faced attacks, cybersecurity governance must evolve with digital growth, since traditional defenses are ineffective against AI-driven phishing exploiting essential digital channels.

B. Vishing

Vishing (voice phishing) is a form of social engineering in which attackers use telephone or voice communication to manipulate victims in order to obtain sensitive information or perform malicious actions. Unlike traditional phishing emails, vishing relies on direct contact—often creating a sense of urgency, authority, or trust, thereby weakening a person's defenses. Digitalization has further exacerbated this phenomenon. With the proliferation of cloud communication platforms, VoIP services, and automated calling systems, attackers now have the ability to make thousands of personalized calls per day at minimal cost. According to the authors in [5] despite the fact that phishing is frequently addressed, voice phishing and SMS phishing which is also known as vishing and smishing are least addressed social engineering attacks. Through vishing and smishing, the attackers try to divulge sensitive information over the phone.

C. Digitization and Related Cybersecurity

Digitalization has transformed organizational efficiency and connectivity but also increased vulnerability to social engineering. As cloud, IoT, and AI tools expand, attackers exploit human behavior through phishing, vishing, and similar tactics that misuse everyday communication channels. Cybersecurity must therefore evolve into a socio-technical discipline, integrating human awareness and secure-by-design principles alongside technical safeguards. Building resilience requires aligning technology, processes, and culture to counter both software flaws and psychological manipulation, since human error remains the weakest link in information security. Effective defense depends on continuous, high-quality staff training that shapes both knowledge and attitude. Management should foster a culture of security and ongoing education to prevent overconfidence, which research shows can lead to risky decisions and greater susceptibility to phishing attacks.

III. Discussion and Implications

As digital transformation deepens, the line between human and technological vulnerabilities blurs. Phishing and vishing exploit this overlap by manipulating human psychology through digital channels, bypassing even advanced defenses. Effective cybersecurity must integrate human factors—combining secure technologies with a strong culture of awareness, accountability, and continuous education.

High-quality training that shapes both knowledge and attitude reduces susceptibility to manipulation, while digital tools like automated network education systems (Matisková et al. [10]) modernize learning. Leadership is essential in fostering proactive security and embedding risk awareness into decisions. True resilience in the digital era relies not just on technology, but on the vigilance and adaptability of people.

References

[1] Gupta, B.B., Tewari, A., Jain, A.K. et al. Fighting against phishing attacks: state of the art and future challenges. Neural Comput & Applic 28, 3629–3654 (2017). https://doi.org/10.1007/s00521-016-2275-y

[2] Iuga, C., Nurse, J.R.C. & Erola, A. Baiting the hook: factors impacting susceptibility to phishing attacks. Hum. Cent. Comput. Inf. Sci. 6, 8 (2016). https://doi.org/10.1186/s13673-016-0065-2

[3] Phishing Activity Trends Report. APWG, 2024-Q2. Available at: https://docs.apwg.org/reports/apwg_trends_report_q2_2024.pdf.

[4] SCHMITT, Marc; FLECHAIS, Ivan. Digital deception: generative artificial intelligence in social engineering and phishing. Artificial Intelligence Review. 2024, vol. 57, no. 12. issn 1573-7462. doi: 10.1007/s10462-024-10973-2.

[5] P. Kumarasinghe, D. Dissanayake, P. Gamage and G. U. Ganegoda, "User Behavior Analysis in Determining the Vulnerable Category of Vishing and Smishing," 2023 5th International Conference on Advancements in Computing (ICAC), Colombo, Sri Lanka, 2023, pp. 35-40, doi: 10.1109/ICAC60630.2023.10417682.

[6] Sherly Abraham, InduShobha Chengalur-Smith, An overview of social engineering malware: Trends, tactics, and implications, Technology in Society, Vol. 32, Issue 3, 2010, Pages 183-196, ISSN 0160-791X, https://doi.org/10.1016/j.techsoc.2010.07.001.

[7] Kathryn Parsons, Agata McCormac, Marcus Butavicius, Malcolm Pattinson, Cate Jerram, Determining employee awareness using the Human Aspects of Information Security Questionnaire (HAIS-Q), Computers & Security, Vol. 42, 2014, Pages 165-176, ISSN 0167-4048, https://doi.org/10.1016/j.cose.2013.12.003.

[8] J.F. Van Niekerk, R. Von Solms, Information security culture: A management perspective, Computers & Security, Vol. 29, Issue 4, 2010, Pages 476-486, ISSN 0167-4048, https://doi.org/10.1016/j.cose.2009.10.005.

[9] Wang, Jingguo; Li, Yuan; and Rao, H. Raghav (2016) "Overconfidence in Phishing Email Detection," Journal of the Association for Information Systems, 17(11), DOI: 10.17705/1jais.00442 Available at: https://aisel.aisnet.org/jais/vol17/iss11/1

[10] Matisková, M., Petija, R., Jakab, F., Feciľak, P. & Kainz, O. Application for creating and automated control of assignments in real and emulated network environment. In: 2021 IEEE 19th International Conference on Emerging eLearning Technologies and Applications (ICETA), Denver, USA: IEEE, 2021, pp. 237–246.

CONFERENCE: **Ulysseus R&I Conference 2025**
SUBTITLE: Navigating Pathways: Digital Transformation of Industry

AUTHOR/EDITOR: Lucia Knapčíková
PUBLISHER: Technical University of Košice
YEAR: 2025

EDITION: First
PRINT: 100 pieces
PAGES: 33
ISBN: **978-80-553-2785-3**

ISBN 978-80-553-2785-3
9 788055 327853