IST-Africa 2026 Conference Proceedings
Miriam Cunningham and Paul Cunningham (Eds)
IST-Africa Institute and IIMC, 2026
ISSN: 2576-8581
ISBN: 978-1-905824-76-2
DOI: https://doi.org/10.67725/IST-Africa.2026.KNSO8398

Capacity Building in STEMS through IoT

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Abstract: Digital Transformation is turning society toward a cyber centred society; this enhanced and key role of cyber technology imposes the need to foster a culture of "cyber". The key subjects to ensure this awareness are STEM. Several governments are fostering educational initiative in STEM as a key building block for a sustainable and harmonic digital society. This paper introduces the state of the art dominated by the ongoing digital transformation and the need to radically improve capacity building specifically in the sector of cyber technologies and related sectors. This implies the boosting of STEM improving the impact of educational resources starting from lower-level schools. Project Based Learning engaging young generation in addressing concrete problems thanks to their own curiosity in developing a personal approach is one of the potential assets. A cooperation between European and African countries can offer a valuable application of these methodologies sharing the experienced PBL approaches developed in EU to African countries having most of the young population and just starting to deal with digital transformation. This approach to education offers a key opportunity to the Global South to scale up its innovation and sustainability on the global scene. Among the different educational approaches Project Based Learning is particularly effective in this sector engaging students in the solution of concrete problems approaching STEM subjects as tools to solve them. This approach favours the so called "deep learning", something that is deep rooted in students. We can assimilate it to the perceptive-motor method that humans use to learn how to ride a bicycle, putting the "hands on" and trying by themselves. This paper describes the foreseen methodology and potential impact of IoT Project Based Learning in an EU-African cooperation framework.

Keywords: STEM, PBL, Capacity Building, Digital Transition, Digital Divide, Cyber Society

1. Introduction

The incredible rapidity of the Internet's success, driven primarily by e-commerce, information services, and, later, social media, paved the way for the so-called Digital Transformation (DT).

Government processes quickly transformed documents and citizen data into streams of data; sometimes under the pressure of critical events, this process was not designed to guarantee security. At the same time, a growing number of "digitally divided" people [1] have been forced to "go digital," generating a larger and more suitable "market" for cybercriminals. The strong desire of decision-makers to go digital [2] has laid the foundations for creating a society based on "digital," a rather fragile pillar, potentially subject to malfunctions, hacker attacks, and susceptible to discrimination from above. This ongoing transformation has outlined the need to align citizens' knowledge and skills to best address the "new normal".

International organizations and governments have invested in programs and strategies designed to enhance the skills, knowledge, and resources of educators, institutions, and students to improve STEM education and research. These programs and strategies, if adopted by governments in the Global South, will produce significant benefits for citizens. Initiatives focus on teacher professional development, providing access to innovative tools and equipment, developing relevant curricula, and promoting a collaborative and inclusive learning environment to improve problem-solving and critical thinking skills. These are precisely the objectives of the capacity-building action plan described below.

2. Objectives

Recent trends have highlighted the significant role of digital technology as a key pillar of today's society; the digital transformation process, implemented at various levels, is undoubtedly impacting society, highlighting the need to improve digital awareness and create a "Digital Culture". Strengthening scientific and technological capacity has been one of the WSIS's action lines since its first phase in 2003; action line C4 "Capacity Building" is coordinated by UNESCO and promoted by UNESCO IFAP. "*Everyone should have the skills needed to fully benefit from the Information Society*". UNESCO has led robust and diverse capacity-building efforts through the launch of national, regional, and global-scale trainings, webinars, and online courses in addition supports the development of media and information literacy competencies through capacity-building resources for both policymakers and civil society.

The European Commission has devoted a specific section of the Horizon Europe program to supporting this objective, with a call for proposals targeting projects that provide individuals and institutions with the skills and knowledge necessary for Europe's digital transformation [8]. In this capacity-building framework, open to innovative methodologies, Project-Based Learning is expected to have a specific impact.

Project-Based Learning (PBL) represents a significant shift in education, promoting active, student-centred learning through hands-on projects. In the era of digital transformation, with the widespread adoption of digital technologies and the proliferation of digital devices, this approach expands opportunities for learning and experimentation. The goal of the current capacity-building effort is twofold: first, to improve a solid understanding of digital technologies; second, to learn by doing on problems identified by students, enhancing the transfer of specific knowledge. The key technology used to implement PBL is the Internet of Things (IoT); the project's four objectives are:

- **Objective 1)** Perform an analysis *on challenges and opportunities of motivating teachers and young people to participate in deep understanding experience* by PBL activities concerning IoT application development and the capabilities of AI in education as an inclusive endeavour. In particular, the triggers of engagement and values guiding learning processes are of interest.
- **Objective 2)** Explore *facilitation to transfer PBL from institutional settings to everyday life practice* of young people, aged from 8-20. It is of interest how to address and engage young learners through PBL for IoT developments to become literate beyond applying AI technologies in digital transformation.
- **Objective 3)** Establish a *platform for IoT PBL* support, designed to share PBL knowledge from European communities for informed participation in shaping their values as part of community development. The platform serves as a knowledge base on how to address teachers and young people to become informed facilitators and IoT appliers, respectively.
- **Objective 4)** Expand the scope from individual and local initiatives to programs to *changing institutional learning processes to everyday life-aware transformations* - grounded on the consolidated results of the performed use cases. A fundamental shift in

the formation and guidance of young learners in digital transformation processes in Europe is of societal interest.

3. Vision and Approach

The current vision aims to integrate ethical and inclusive innovation into the technological landscape. Bringing together stakeholders from information and communication technologies (ICT), science, technology, and mathematics (STEM), industry/business, the humanities, and social sciences, it aims to address the diverse social impacts of digital transformations. This interdisciplinary collaboration ensures that proposed technological advances are accessible, transparent, and beneficial, reducing inequalities and promoting inclusivity for all social groups. Central to this approach is the empowerment of end users and workers as "human beings." By actively involving them in the technology development lifecycle, promoting a participatory design process. This approach not only improves the relevance and adoption of these technologies but also ensures they are aligned with real-world needs and ethical standards. This involvement fosters a sense of transparency and ownership among providers and users, which is crucial to the widespread acceptance and success of technological solutions. The commitment also extends to promoting social innovation, particularly in critical sectors such as healthcare, mobility, and public administration, which are essential in the digital future. The goal is to create frameworks and tools that encourage innovation, ensuring it translates into concrete improvements in everyday life, while respecting ethical practices.

The approach promotes technologically advanced and socially acceptable innovation, ensuring that such innovation is aligned with the values of inclusiveness, data access, and equity. It focuses on preparing society for upcoming transitions by improving skills and capabilities that encourage citizens' adaptability and resilience. In addition, it addresses the risks associated with digital transformations, such as digital gaps, skills mismatches, top-down control, and security vulnerabilities. Targeted interventions are designed to effectively mitigate these risks, ensuring a safe and equitable digital future. The project achieves this goal by developing transparent guidelines, information on ownership and copyright, and best practices for the ethical implementation of technology, prioritizing respect for individual privacy, user rights, and social values.

4. Deep understanding: the goal

The project draws inspiration from the recent recognition of Wagenschein's principles for facilitating in-depth understanding of a topic (Wagenschein, 2023[1]). He uses the term " **enracinement**" in the Simone Weil sense. It denotes the "rooting" of knowledge and the sustainable embodiment of technical skills. Deeper understanding can be achieved by replacing young people's access to information sources and reproducing exercises, allowing them to experience how their insights on a given topic have evolved: "formatio" (training) replaces "informatio," or the consumption of well-prepared content and products. Therefore, the role of teachers is to facilitate individual understanding by "observing firsthand how things happen" [18 - Wagenschein, 1968, p. 120]. Replacing knowledge transfer with this kind of knowledge construction, facilitators not only need patience, but also the ability to tolerate helplessness to develop sustainable insights and deep understanding.

If young people know how to follow a sequence of steps to create a technical artifact like an Internet of Things (IoT) application or apply a formula, they can program an application or calculate a number. But when young people are able to describe the content of functions or the calculation of a formula in their own words, based on individual

[1] https://www.fhnw.ch/plattformen/wagenschein-tagung/programm-2023/

experiences, knowledge and the correct use of a programming language or formula are triggered by a deep understanding. When we want to enrich the value of knowledge to "understand" it, the exemplary nature of the object must become the goal of knowledge construction [18].

Intuitive observation and individual experience are at the heart of facilitation and learning, and are being removed from hasty knowledge, classification, explanation, and judgment, especially in times when a language-based answer to every question can be quickly found in the digital infrastructure (although ChatGPT 5.x has yet to deliver on its promise of PhD-level expertise).

An example of an IoT-PBL project for everyday use, specifically modelled for African regions characterised by scarcity of water, and therefore a transfer case, is the development of a CPS (Cyber Physical System) self-watering application for a family. A self-watering pot uses integrated sensors and automation systems to monitor and deliver water to houseplants as needed. It consists of a water reservoir at the bottom of the pot, soil humidity and temperature sensors, a capillary system that transports water from the reservoir to the soil, and a microcontroller or smart device that monitors temperature and humidity levels and controls water flow. The application can be designed physically using IoT devices and digitally using a Digital Twin (DT) to simulate its operation before being deployed in a household. The system automatically detects when the ambient temperature exceeds a critical threshold or the soil is dry and releases water, reducing manual watering and preventing both under- and over-watering. The system keeps plants watered during busy weeks or vacations.

The CPS application is connected to an IoT cloud and sends notifications and tracking data via a smartphone App. Families can monitor plant health via the app's dashboards and learn about plant needs and responsible watering without any manual intervention. The main advantages are not only the in-depth understanding of the PBL-IoT cloud-based management, with and without AI enhancements, but also the connection to sustainability issues related to digital transformation, such as water efficiency: water waste is reduced by dispensing only what is needed. Another important aspect is improved plant health, as optimal soil moisture is ensured, promoting lush growth. Finally, social sustainability comes through family involvement, as smart features can involve the entire family in plant care through app monitoring and alerts.

A deep understanding of IoT is therefore an individual enlightenment. It often does not happen during school lessons, as such institutional settings do not allow for in-depth understanding. Instead, they leave young people feeling doubtful and uneasy even when they are interested in the topic. This action plan encourages individual ecosystems to work on IoT topics of personal interest through exemplary means. Exemplary means indicate a careful selection of application cases for achieving competencies. While there is not a catalogue of topics to explore, "exemplary" is not intended to justify the choice of a topic. This action plan focuses on personal interest in everyday needs or innovative solutions for everyday use. Creating a meaningful future in this way includes neurodivergent students through active participation, as recently demonstrated [16].

The empowerment of teachers and young students will be achieved by applying an experience- and value-based approach to reflect on the skills and processes for developing IoT capabilities structured by PBL (IoT-PBL), from both an individual and collective perspective. The project's ambition, with specific reference to the African countries is

- to enable the African young generation to gain a deep understanding of IoT application development and, in this way, qualify them in advance for the digital transformation of their personal ecosystem.

The overall objective is to establish IoT-PBL coaching for educators and the related learning support infrastructure as effective means of educational transformation, facilitating young people's informal capacity development processes in adopting cyber-physical technologies for their personal use.

5. PBL Courses Implemented in Europe

No official report provides an exact and authoritative number of European schools using PBL in technology subjects. Major European reports on STEM and education, such as the "European STEM Schools Report: Key Elements and Criteria" by European Schoolnet [12] and publications from the European Commission's Joint Research Centre, highlight the inclusion and importance of PBL in technology/STEM education, refer to pilot studies and school self-assessments, and present qualitative criteria, but they do not provide precise, continent-wide counts regarding the adoption of PBL in technology subjects. The European STEM Schools Report [12] interviewed and consulted stakeholders in nine countries and identified PBL as a key criterion for STEM schools, while the European Commission's STEM policy reports highlight the need for more systematic research and data collection, acknowledging the lack of robust statistics on school-level PBL adoption rates in technology subjects[2].

Driven by this research need, the project aims to reach young people both in their school environment and in their daily lives and practices. We will take full advantage of the IKEA effect in relation to IoT by following its rules: *(1) People (might) like what you offer them; (2) If you want people to like something, let them build it; (3) If you want people to love something, let them help shape it.* To shape the development of IoT, formal learning didactics in schools will be considered together with informal learning didactics, enabling young people to pursue learning based on their own interests and needs. Education should be perceived through opportunities, that is, opportunities to interact with the environment in ways that reflect the needs and plans of young people. Learning should be guided by curiosity[3], intrinsic motivation, and real-life experiences. Doing and perceiving should be accompanied by Thinking, Feeling, and Belonging [6 - Beard, 2022, p. 64]. Cognition can become an active process of sensemaking, arising from the dynamic and continuous interaction between an organism and its environment through sensorimotor coupling instead of the traditional symbolic / reconstructive approach. The possibilities for guiding students as facilitators will be explored with the help of teachers, AI agents, and Agentic-AI platforms. AI agents will be explored for specific topics, such as IoT application architecture, digital twin engineering, and creative learning experiences, while Agentic AI is ideally suited to support the facilitation process and PBL workflows. The work will be aligned with recent empirical evidence on AI-supported PBL. Furthermore, for IoT-PBL, an AI-based Project Bot will accumulate IoT-PBL knowledge for immediate reference. Finally, students will develop prompting and verbalization skills using LLM-based tools such as perplexity.ai.

A key technical achievement is the integration of dedicated AI components into an ecosystem of Open Educational Resources (OER). AI bots are being developed to personalize learning processes within PBL contexts, enable formative assessments, and serve as tutoring tools. Particular attention is paid to integrating the fundamentals of AI teaching methods into PBL tutors, such as tools for verifying the validity of AI statements; exercises for developing critical thinking, and action approaches in response to bots' responses. The resulting bots can be integrated into a variety of digital environments via a web interface and used in both formal and informal learning contexts.

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[2] https://education.ec.europa.eu/news/stem-education-report-highlights-need-for-more-policy-efforts-and-research
[3] This reminds Steve Jobs' – "Stay hungry, stay foolish"

6. Methodology Used

Project-based learning (PBL) is a student-centred, project-based teaching and learning model [20 - Zhou, 2023]. IoT projects are complex tasks, based on challenging questions or problems, that engage students collaboratively in planning, problem-solving, decision-making, and implementation. Artificial intelligence software and applications will be developed on cloud-based IoT (e.g.. https://www.euro-stack.info/). By integrating IoT technologies into the PBL, the initiative promotes digital literacy, critical thinking, and problem-solving skills among students and teachers. These are key skills for both digital transformation, as digital tools and AI-based solutions are essential for energy efficiency, resource management, and sustainable innovation. Through IoT projects in their daily lives, students gain autonomy and responsibility, develop skills, apply knowledge, and learn meaningfully. To implement this socio-constructivist concept, teachers who integrate PBL into their teaching move from traditional practice to student-centred facilitation. This becomes even more essential given the current trend of designing entire curricula according to PBL [14 - Mitchell et al., 2024]. Teachers, as facilitators, work closely with students, addressing a concrete challenge or exploring a meaningful question.

Students actively explore real-world problems and challenges and gain deeper knowledge. Teachers and students work together to initiate and complete projects. Students develop understanding and complete projects. Once familiar with PBL, teachers share best practices and seek inspiration when collaborating with external stakeholders to make learning relevant and authentic [15]. The project goes beyond the current state of the art in five key ways:

- **From adoption to deep understanding and empowerment:** Most current research and implementations focus on the adoption and acceptance of IoT in educational contexts, emphasizing factors such as technological optimism, perceived usefulness, and initial motivation to use IoT tools [13]. While these studies highlight the importance of infrastructure, teacher training, and curriculum adaptation, they often focus on introducing IoT as a technological support or supplement to traditional instruction. The project goes further, integrating IoT not only as a tool but as a fundamental element of PBL, making it central to both pedagogy and student action. Actively transforming the role of teachers from technology users to empowered facilitators and learning coaches, promoting deep and self-regulated understanding in students.
- **Focus on metacognitive and self-regulation skills:** Although the current state of the art recognizes the need for digital literacy and practical experience with IoT, little emphasis is placed on systematically developing students' metacognitive and self-assessment skills through IoT-based projects [4]. The project-based approach explicitly targets these higher-level skills, providing students not only with the tools to use technology but also to reflect on, evaluate, and transfer their digital skills to real-life contexts.
- **Organizational scale, systemic change, and scalability:** Research highlights the importance of professional development and infrastructure but often focuses on isolated pilot programs or interventions in individual classrooms [13]. The project is designed for systemic impact: it aims to implement learning streams that go beyond curricula. It engages entire schools, including management, and offers a scalable model for regional and national adoption. The project team provide comprehensive coaching, technical support, and a framework for the sustainable integration of IoT and project-based learning into digital literacy programs (development).
- **Hands-on student training:** Although many studies recommend aligning IoT with real-world applications, implementation in everyday scenarios often remains abstract or limited to STEM subjects [4]. The foreseen methodology directly engages students with authentic, everyday problems relevant to their lives, aiming for meaningful learning

outcomes. Mentors encourage the co-creation of learning scenarios, with students as active problem designers and solvers, not just passive users of IoT tools.

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- ***Evidence-Based, Transferable Best Practices:*** The foreseen methodology not only implements innovative transfer practices from institutional experience to everyday life in terms of active capacity development, but also systematically documents, evaluates, and disseminates the results [15]. This creates a repository of transferable, evidence-based governance frameworks for other schools, institutions, and regions, a step forward compared to most research, which often lacks mechanisms for broad dissemination and scalability.

The project team follow the Design Science methodology, as it involves the structured and traceable integration of previously isolated concepts and practices and is adapted to engaging PBL contexts [9]. By applying Peffers et al.'s [17] methodology, the project's objectives can be achieved through well-defined and structured phases:

1. ***Identification of object and motivation***: This initial step details the need and benefit of digitally supported coaching to qualify teachers as catalysts in transferring institutional knowledge on project-based learning and/or IoT to students' everyday life, and to be role carriers for transformative education.
2. ***Definition of objectives for a solution***: Meaningful PBL reflections and transfer designs through digital coaching along PBL supports qualifying educational ecosystems for knowledge transfer into everyday lives of students.
3. ***Design and development of an artefact***: An artefact can be a model, a concept, a method, an object, an application or a combination of those. In this project, the artefact is a governance scheme for teacher coaching in transformative education through project-based IoT capability development, based on a digital infrastructure and methodological know-how. The latter enables students to develop and implement IoT projects in their life practice.
4. ***Demonstration***: In each Design Science cycle transfer scenarios from institutional project-based IoT learning to life practice are co-designed with local educational organizations.
5. ***Evaluation***: In each of the Design Science cycles the current coaching solution for a transfer case with schools is evaluated by qualitative methods focusing on digital literacy development.
6. ***Communication and Dissemination*** of all achievements, including the coaching and transfer artefact, to other educational institutions, researchers, and practitioners.

The implementation program foresees a three-year commitment divided as follows: the first year is dedicated to the detailed definition of training and transfer requirements (see 1. and 2.) to develop a learning environment for IoT-PBL for teachers and transfer support from school to daily practice. Identification of African relevant pilot cases with partners experienced in IoT-PBL and capacity building for teachers are part of the initial design cycles for fourth- and fifth-grade students in selected schools (while the other partners observe and develop methodological skills to facilitate IoT-PBL). They play a key role as sparring partners and provide their unique expertise as scientific advisors in STEM education, Cognitive Science, and Human-computer Interaction.

In the second year, additional partners/partner sites will be involved both across African Countries and Europe in the follow-up design cycle, which will culminate in the third year in distributed projects across African countries to implement virtual exploration labs. Once the design cycle is completed, the documented experiences will be communicated and thus incorporated into the dissemination and exploration activities. The artifact, composed of coaching skills for transfer and facilitation and the Digital IoT-PBL Suite, is generated during the design activities.

Therefore, each design cycle corresponds to a dedicated learning phase. Starting in the first year, a first version of the IoT-PBL Suite will be developed and implemented at the micro level, with selected fourth- and fifth-grade participants. In the framework of EU-Africa cooperation this segment will include integrated Mobile Makerspace and Nerd40, as well as methodological transfer expertise. The second and third years will subsequently address the macro levels, both in terms of classroom contexts (from individual student transfer cases to collaborative and distributed cases) and integrated IoT-PBL learning support methods and technical features (complementing existing IoT learning support and enriching it with Digital Twin modelling and facilitation and coaching support). Each year, one partner takes the lead in further developing the transfer cases, while all other partners leverage existing experiences and monitor ongoing developments. This controlled progression focuses on ongoing stakeholder engagement and their input on how to ultimately scale the IoT-PBL approach.

The design of learning support for teachers will begin in the first year and will subsequently be improved based on teacher feedback and the results of IoT-PBL use cases. Transfer support will be designed based on Value Network Analysis (VNA) [3] and will be aligned with PBL interventions [5]. Using the appropriate VNA, teachers who become facilitators can reflect on and continuously improve their learning support in PBL. In this way, PBL frames the application of VNA through success factors and guidelines for effective PBL practice. The PBL success factors and guidelines are linked to value transactions between PBL stakeholders and considered from the facilitator's perspective.

To make the existing potential for change tangible, the method leads to the development of proposals as concrete offers to other stakeholders. Once accepted at the organizational level, their implementation completes the planned collective learning phase.

Value network analysis supports the development of facilitators in PBL [5]. It allows for continuous improvement of the learning support provided by facilitators based on essential success factors and guidelines for effective PBL. They aim for individualized and targeted learning through self-organized problem-solving processes. When working on authentic topics, learning processes focus on collaboration and feedback. The latter is part of understanding the teacher's role as facilitator and is essential for achieving learning objectives. The VNA process in the context of PBL requires six steps: informing, creating a holomap (i.e., a diagrammatic representation of the actors involved in IoT-PBL and their value exchanges), conducting an exchange analysis, conducting an impact analysis, conducting a value creation analysis, and adapting the holomap (https://netopapa.github.io/holomap/).

Complex Adaptive Systems, as actors in the ecosystem in question, are the agents of change within that system, while Genetic and Organizational Learning addresses deep learner understanding and guided role change toward facilitation, resulting in collective transformation. Depending on the evaluation results in each design cycle (Design and Development - Demonstration - Evaluation), for each transfer case, the solution achieved must be improved while maintaining the set of requirements unchanged, or it can be enriched. The project's design artifact is the educational transfer support environment. This is a technical component of the Suite; its social and organizational component includes coaching support for educators, to facilitate IoT-PBL processes toward in-depth understanding.

The finally developed Digital IoT-PBL Suite is conceptualized as a federated system (i.e. each component can run standalone and in combination with other components) and comprises the above-mentioned development support tools and contains all infrastructure solutions for practical IoT development (nerd40.ce.jku.at), all support components for learning and digital transfer for IoT-PBL (value network analysis tool for PBL, IoT Skill Development Base, IoT Project Bot, support components via AI agents for architecture, PBL, Digital Twin (DT) modelling and coding, and agentic AI for runtime problems, including validation of DT models and CPS checking by DTs.

7. How to impact the educational system

The project targets schools and educators, establishing an EU – African countries cooperation, ensuring that the next generation is not only digitally competent, as required by institutional education, but also capable of applying these skills and artificial intelligence to real-world challenges in everyday life, by facilitating learning outside of school[4]. This shift is aligned with preparing young people for active participation in an innovative and sustainable ecosystem and economy undergoing digital transformation. The action plan promoted by the project is particularly relevant for the Global South and specifically African countries, offering the opportunity to foster innovation and potential scientific competition. Above all, it targets educators and supports the ongoing formation of international alliances in the economic and educational sectors, transcending institutional boundaries.

As humanity and democratic systems today face unprecedented challenges, it is necessary to proactively address profound social and global digital transformations. IoT-PBL fosters social sustainability and resilience in this regard, as in this project, teachers and young people are encouraged to create a meaningful future for themselves through active and inclusive participation in a diverse and pluralistic digital literacy initiative. The project explores transfer effects on the development of inclusive capacity building and on transformation processes relevant to society, open to the entire neurodivergent spectrum of students, and therefore must be based on disciplinary impact-oriented integration of the topic in social sustainability intelligence development with the concrete of technology including AI tools integration geared towards the impact of the topic in developing intelligence for social sustainability with the concreteness of technology, including artificial intelligence tools.

The action plan will encourage the creation, access, distribution, and promotion of PBL content across all sectors of education, considering the digital transition, which encompasses both everyday life and technological dimensions. The impact of IoT technologies on societally relevant digital transformation processes will be systematically assessed through IoT-PBL profiles of knowledgeable stakeholders in the education sector. Furthermore, the international project team will engage in research and advocacy on education-related topics among cross-border audiences to strengthen policies, institutions, and civil society organizations, formulate recommendations for inclusive citizen development, and adapt transition strategies for broader policy development. The action plan partners firmly believe in the sustainable impact of this transfer experiment and are designing it to be engaging, meaningful, and provide awareness, education, and recommendations on digital transformation.

The social sustainability of this project will be implemented through meaningful engagement with all stakeholders, including the selection of topics that reference the Sustainable Development Goals (SDGs), such as IoT applications relevant to the climate crisis, or efficient use of energy and water. Thus, the approach will achieve both a deep and

[4] see the new European Bauhaus initiative transforming schools into living laboratories (https://eco2-schools.eu/)

broad impact, aiming to modernize future workforce development and promote participation in digital transformation processes, fostering the creation of new enterprises and working positions on site. Its relevance to everyday practice ensures adequate motivation and skills policies and strengthens social cohesion and resilience. Both are *conditiones sine quibus* for digital transformation in an era of demographic change and significant technological advances in African countries. Regular reporting on impactful activities will contribute to a better understanding of the role of global learning value chains through IoT-PBL, delivering measurable social impact and strengthening societal resilience through effective learning transfer.

8. Conclusions

Some time ago, one of the recurring themes was the "digital divide" and the need to bridge it. Almost simultaneously, we addressed the concept of capacity building, specifically focusing on digital technology: UNESCO IFAP had been promoting digital media literacy for over twenty years. These themes were primarily aimed at public sector workers and employees to better address the ongoing innovation in the public and private sectors. Thanks to the spread of video games, tablets, and smartphones, younger generations seemed to be digital experts, so no specific actions were implemented. Consequently, the idea was to patch things up and wait for the younger generations to take over. This approach had the side effect of failing to address the education sector at various levels, sometimes neglecting the need to train educators. Often, younger generations' ability to use digital devices does not imply adequate knowledge of digital technologies; they often have a superficial understanding of how to use technology, passed down from friends, social media, or built through trial and error. This approach falls within what we have defined as "informational" knowledge; this level does not allow for "deep understanding"; they cannot move beyond the end-user level of the technology, with limited opportunities for breakthroughs. To achieve a deep understanding, two options arise: a strong commitment as a self-taught individual who researches the literature and experiments with technology in the field, or the development of a curriculum, a methodology that enhances teachers' specific knowledge and implements a capacity-building methodology capable of "embedding" a deep understanding. It is time to move to the next level of education. The accelerated digital transformation process, further fueled by the recent pandemic, has placed digital technology, with all its vulnerabilities, at the center of the new normal, transforming the idea of improving "digital culture" into a must, starting with children. Compared to Europe, African states enjoy a double advantage: the preponderance of young generations and the recent activation of the digital transformation process.

Acknowledgements

Declaration of use of content generated by Artificial Intelligence (AI) (including but not limited to Generative-AI) in the paper

The authors confirm that there has been no use of content generated by Artificial Intelligence (AI) (including but not limited to text, figures, images, and code) in the paper entitled "Capacity building in STEMS through IoT".

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