Entrepreneurial attitude for social inclusion across AI-driven Phygital solutions

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Abstract

Frame of the research. *The Phygital approach, blending physical spaces with AI-enabled digital tools, is emerging as a promising model for inclusive education. From this perspective, the creation of an experimental Phygital space allows the integration of traditional and digital methodologies, reshaping learning processes and redefining the roles of both learners and teachers.*

Purpose of the paper. *This study explores the Phygital Center as a viable approach that combines digital platforms and physical spaces to deliver personalized entrepreneurial education. It aims to foster entrepreneurial attitudes among disadvantaged groups, helping to overcome socio-economic barriers and build sustainable, inclusive learning ecosystems.*

Methodology. *The paper adopts a theoretically informed, exploratory case study design. A narrative literature review supports the conceptual framing, while the case of a Phygital Centre located in Catania, Sicily (Italy), serves as a revelatory example to theorize how hybrid infrastructures can support inclusive, entrepreneurial learning experiences.*

Results. *Although still in progress, the Phygital Centre is expected to enhance learner motivation and engagement through personalized content, immersive simulations, and mentoring. Its hybrid structure is designed to strengthen employability skills and support the development of personal initiative and entrepreneurial orientation among NEETs, migrants, and other disadvantaged populations.*

Research limitations. *The study focus on a single territorial case study that is still under development, limiting generalizability. Further research, including longitudinal and comparative analysis, is needed to assess long-term impacts and broader applicability.*

Managerial implications. *Phygital models provide a strategic framework for scalable, inclusive learning environments. For policymakers and educators, they highlight the value of hybrid infrastructures, AI-based personalization, and cross-sector collaboration in enhancing vocational pathways.*

Originality of the paper. *This paper offers a conceptualization of the Phygital model as a generative framework for social inclusion. It contributes to inclusive education and service innovation literature*

Keywords: *Phygital; Social Inclusion; AI-Driven learning; Digital Transformation; Entrepreneurial Attitude*

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1. Introduction

This study explores the convergence between educational innovation and social inclusion, with a particular focus on the design of technology-supported learning environments tailored to the needs of marginalized populations. As inclusive education gains increasing prominence in both theoretical and policy agendas, growing attention is being directed toward hybrid models that strategically combine the efficiency of digital tools with the relational depth and transformative potential of human-centered engagement.

The term "phygital" refers to the seamless interlinking of the physical and digital environments. Initially limited to retail, this emerging model has now expanded to numerous sectors, including education, healthcare, and public services. The "phygital" experience gives rise to hybrid interactions that combine the best of both worlds, which enables increased personalization, accessibility, and scalability. From an educational and social inclusion perspective, phygital environments provide a feasible approach to engaging disadvantaged populations, such as NEETs (young adults not in employment, education, or training), migrants, and inmates, who are often excluded from traditional services (Del Vecchio *et al.*, 2023).

Theoretically, a phygital model is rooted in accessibility and inclusiveness principles underpinning service innovation and social policies. Providing a path to transcend socio-economic barriers, it offers an opportunity to re-think traditional models of service design and delivery. The integration of digital tools (for example, AI-based learning platforms) with physical support systems creates a holistic ecosystem capable of tackling the educational and social challenges faced by marginalized groups (Schneider, 2021). That ability to adapt and respond is especially critical in connecting with students without formal schooling or the means to engage fully in a digital-first world.

Digital platforms provide global access to learning assets and individualized support, while physical hubs facilitate meaningful interaction with mentors and peers. This dual-channel approach promotes deeper engagement and stronger learning results, validating the theoretical premise that hybrid settings can meet a wider range of learner needs more efficiently than either digital-only or physical-only models (Mele *et al.*, 2023). In doing so, the phygital model emerge as a key enabler for broad societal impact.

In this paper, we analyze the application of the Phygital model in the context of GRINS project, (Growing Resilient, Inclusive and Sustainable), an extended partnership, funded by the PNRR (Italy's National Recovery and Resilience Plan), Mission 4 (Education and research), Component 2 (From Research to Business), Investment 1.3 (Extended Partnerships), Theme 9 (Economic and financial sustainability of systems and territories), which generates frontier research in the field of economic-political-social sciences and data sciences to create scientific evidence that can help in the landscape of public policies, as well as citizen and company choices in complex decision-making scenarios.

The creation of the Phygital Center for GRINS Project is part of the ecosystemic strategy of entrepreneurial education inspired by the "third mission" of universities. It reflect the vision of an Entrepreneurial University as proposed by Audretsch (2014), which contributes to the generation of entrepreneurial capital also through educational initiatives. In this vision, entrepreneurial education must involve the entire university structure and extend beyond it, engaging with society at large.

In this perspective, entrepreneurial education encompasses a path that leads from knowledge, to skills, to entrepreneurial attitude through a wide range of activities, addressing not only students, researchers, and academic actors, but also external users in the broader ecosystem, particularly disadvantaged groups. These individuals are supported in developing their entrepreneurial mindset and recognizing untapped skills through personalized training experiences based on AI-driven technologies in the Phygital Centre (Nicotra *et al.*, 2021).

To optimize the re-skills and up-skills educational pathways within the Phygital Center, the project also includes the development of a Data dictionary for skill management designed to support the customization of learning experiences, solutions, and services offered to disadvantaged groups. This model is scalable at the national level, with implications for future policy and educational planning.

The structure of the paper is as follows: Section 2 describes the methodological approach adopted. Section 3 outlines the theoretical foundations of the Phygital model and its relation to social inclusion. Section 4 discusses the enabling technologies. Section 5 presents the GRINS Phygital Centre as a case study. Section 6 addresses managerial and policy implications, and Section 7 concludes the paper with final remarks and future research directions.

2. Methodology

Given the conceptual and exploratory nature of this study, the research adopts a qualitative approach grounded in a single-case study design (Yin, 2009; Eisenhardt, 1989). The aim is to investigate how Phygital models, conceived as hybrid infrastructures integrating digital and physical elements, can act as enablers of entrepreneurial education and social inclusion, especially for marginalized populations. Rather than testing hypotheses or producing generalizable results, the research focuses on generating theoretical insights by examining a relevant and innovative case.

In line with the interpretive tradition, the selected case is considered revelatory (Siggelkow, 2007), offering access to a context where a novel educational infrastructure is currently being designed and implemented. While the Centre is not yet operational, the documentation and planning processes offer rich material to analyze its conceptual architecture and intended impact.

The methodological approach combines two interrelated components. First, a narrative literature review was conducted to build the conceptual framework underpinning the study. The review focused on scholarly contributions in four thematic areas: digital transformation and agility; service innovation and hybridization; entrepreneurial education for inclusion; and AI-based personalization in learning environments. Sources were selected through targeted searches in academic databases such as Scopus and Web of Science, using keyword combinations reflecting the core concepts of the study. The review was interpretive in nature and aimed at synthesizing relevant knowledge to inform the theoretical positioning of the Phygital model.

Second, the paper presents a case study centered on the development of a Phygital Centre within the GRINS Project (Growing Resilient, Inclusive and Sustainable), a national research and innovation initiative funded by Italy's Recovery and Resilience Plan (PNRR). The Center is located in Catania (Sicily) and illustrates how a Phygital infrastructure is being conceptualized and designed to provide personalized, inclusive training pathways for disadvantaged groups such as NEETs, migrants, and inmates. Data were collected through document analysis, including project proposals, internal reports, technical documents and workshop materials produced during the design and prototyping phases.

Given the early stage of implementation, the analysis does not aim to evaluate results, but rather to conceptually explore how the Phygital approach can be operationalized as a model for social inclusion through entrepreneurial learning. The insights generated contribute to ongoing theory building and may serve as a foundation for future empirical investigations across a variety of socio-economic and institutional contexts.

3. Theoretical Background

Although digital transformation and new digital business models have significantly influenced various sectors, academic research has only lately commenced a systematic investigation of digitization, digitalization, and digital transformation (Venkatraman, 2017; Verhoef *et al.*, 2021). User behavior has undergone significant changes due to digital transformation, with online buying and digital touchpoints becoming essential components of each kind of experience (Kannan & Li, 2017). Digital transformation is especially crucial for established organizations, since they encounter difficulties in assimilating new digital business models due to legacy limitations (Markides, 2006; Christensen *et al.*, 2016). Some organizations are progressively undergoing digitization and

digitalization, while others face the threat of obsolescence if they do not adapt (Teece, 2010). This transformation allows organizations to utilize digital technologies for cross-border interactions (Singh & Hess, 2017), thereby fostering the achievement of a competitive advantage through the enhancement of existing core competencies or the creation of new ones (Liu *et al.*, 2011).

Recent search and social media tools have enabled users to be more interconnected and knowledgeable (Lamberton & Stephen, 2016; Verhoef *et al.*, 2017). Digital platforms currently enable co-creation, allowing consumers to build and customize items, engage in last-mile distribution activities, and share product feedback (Grönroos & Voima, 2013; Beckers, van Doorn, & Verhoef, 2018). The intersection between digital transformation and education has attracted increasing scholarly interest in recent years, as digitalization becomes a key enabler of inclusive learning practices. At the heart of this convergence, Phygital learning models propose hybrid solutions that integrate the personalization capabilities of digital tools with the human-centered value of in-person support, particularly in fostering re-skilling and up-skilling pathways for marginalized groups.

By incorporating these principles in aims of social inclusion, the Phygital Hub approach visualizes and edit the digital customization for socially disadvantaged populations of NEETs, migrants, prisoners, and people with disabilities. An arficial Intelligence (AI) -based data platform assess user data to tailor learning path, ensuring that academic content aligns with individual growth and needs. Augmented Reality (AR) technologies intensively enhance personalization, while community-oriented physical hubs provide essential face-to-face support (Silvia *et al.*, 2023). While augmented reality enhances immersion and personalization, its link to digital agility lies in enabling users to rapidly adapt to new interfaces and learning scenarios, thus fostering organizational responsiveness

Digital agility, which is the ability to detect and leverage opportunities offered by digital technology, is vital for survival in today's fast-paced markets (Lu & Ramamurthy, 2011; Tallon & Pinsonneault, 2011; Lee *et al.*, 2015). Organizations using this capability adapt to changing users demands and technological upheaval quickly (Chakravarty *et al.*, 2013). Managing the complexities of digital transformation requires organizations to constantly reconfigure their existing digital resources and capabilities (Lavie, 2006; Eggers & Park, 2018; Romano et al, 2021). Digital agility in Phygital Center drives integration between digital assets and organizational resources towards creating innovative business models and training programs (Sambamurthy *et al.*, 2003; Teece, 2010; Karimi & Walter, 2015). This approach can foster continuous improvement, ensuring that educational programs remain relevant, impactful, and accessible to underserved communities.

Digital networking capabilities enable learners to engage across geographical boundaries (Libert *et al.*, 2016; Koch & Windsperger, 2017). Phygital Centres strengthen their outreach through structured collaborations with schools, businesses, and public institutions, positioning themselves as strategic nodes within broader education and social inclusion policies. This transition is supported by big data analytics, which facilitate informed decision-making through systematic access to and interpretation of learning data (Loebbecke & Picot, 2015; Dremel *et al.*, 2017). Addressing the challenges of digital transformation (Eggers & Park, 2018; Sklyar *et al.*, 2019) requires an evolution of the Information Technology (IT) function toward active contribution in educational value creation (Leonhardt *et al.*, 2017). In this perspective, key performance indicators (KPIs) must go beyond traditional economic metrics, incorporating measures of engagement, inclusion, and learning effectiveness (Verhoef *et al.*, 2016). Within Phygital Centres, KPIs are redefined to reflect both individual-level outcomes-such as participation, completion, and employability-and system-level objectives aligned with scalable and inclusive policy frameworks (Verhoef *et al.*, 2015; Lemon & Verhoef, 2016).

Digital and physical components are intertwined not only to enrich user experience but also to optimize resource efficiency. Through ICT-enabled delivery and localized support, Phygital experience reduce educational costs while maintaining high-touch engagement that can make a critical difference in learner success (Mele *et al.*, 2023); technology-based platforms offer scale and flexibility, they often lack the personal engagement needed to ensure participation and retention. The phygital model overcomes this limitation by integrating both modalities within a unified system,

combining the benefits of digital content with the social presence provided by physical environments (Del Vecchio *et al.*, 2023).

In vocational training, for instance, the phygital model enables learners to complete online simulations and theoretical modules while participating in hands-on workshops. This is especially valuable for groups such as inmates, NEETs, and migrants, who benefit from digital inclusion but also require social interaction and practical skill-building (Gelsomini *et al.*, 2021). Educational phygital models are evolving alongside service systems, as both increasingly rely on personalization and hybridization.

These thematic trends have been identified through a Structural Topic Modeling (STM) analysis based on a systematic literature review by Virgillito *et al.* (2024). Seven key domains emerged where phygital applications are gaining relevance: (1) Metaverse; (2) Health Technology, Cultural Heritage, and Gaming; (3) Fashion & Luxury; (4) Customer Experience; (5) Education; (6) Tourism; and (7) Retail Experience. Among them, the education domain is particularly relevant to this study, representing a convergence of technological innovation and inclusive pedagogy.

Phygital education merges traditional classroom techniques with digital learning, surpassing the purely digital models adopted during the pandemic and reconfiguring both teaching and learning roles (Zaitseva *et al.*, 2023). It is particularly suitable for Generation Z, often referred to as the phygital generation. Researchers in the educational field are increasingly exploring how this approach enhances instructional effectiveness.

Existing studies demonstrate that phygital surroundings can enhance the teaching process in several ways (Fonseca & Mealha, 2022; Del Vecchio *et al.*, 2023; Zaitseva *et al.*, 2023). They support innovative methods, such as using smartphones for collaborative learning or phygital textbooks for immersive experiences that foster active participation.

This aligns with the broader goals of Entrepreneurial Education (EE), which aim to prepare learners to be adaptable and opportunity-oriented. EE is intended not only to build entrepreneurial competencies (Gibb, 2005; Nicotra *et al.*, 2021) but also to improve student engagement, motivation, and perceptions of educational relevance (Malsch & Guieu, 2019). As the nature of work continues to evolve, EE becomes crucial to building employability and resilience.

Within this framework, the Phygital Hub emerges as a practical model for integrating theoretical knowledge with experiential learning. Its digital dimension ensures accessibility and flexibility, while its physical spaces support mentoring, professional networking, and problem-solving. This is especially relevant for disadvantaged groups, enabling them to develop the cognitive and applied skills needed to enter entrepreneurial ecosystems.

Finally, the phygital perspective resonates with experiential learning theories, which emphasize the importance of action and reflection in educational processes (Mele *et al.*, 2021). By anchoring learning in both digital and real-world contexts, Phygital Hubs bridge the gap between education and employment, facilitating direct pathways into the labor market-particularly for those facing systemic exclusion.

4. Key Technologies Driving Phygital Experiences

The technological infrastructure of the Phygital Centre is built around three core components: artificial intelligence (AI), augmented reality (AR), and immersive environments. These technologies, integrated within a cloud-based and adaptive architecture, enable the delivery of personalized, scalable, and inclusive learning experiences for disadvantaged groups.

AI serves as the backbone of the personalization process. By analyzing behavioral data, performance indicators, and individual learner profiles, AI systems support the creation of customized educational pathways. This continuous adaptation helps maintain learner motivation, reduces the risk of dropout, and allows content to evolve in real time, in line with each learner’s progress (Pironti,

2022; Bini *et al.*, 2023). In the context of the Phygital Centre, AI is not just a digital tool, but a strategic enabler that aligns educational goals with personal and professional development needs.

Augmented reality further enhances the experience by layering digital information onto physical spaces, creating interactive, multisensory learning environments. AR has proven especially effective in vocational contexts, where learners can practice real-world tasks in virtual form before applying them in hands-on settings (Damala & Stojanovic, 2012; Mele & Russo-Spena, 2022). This lowers cognitive and emotional barriers, particularly for learners who may feel excluded from formal education. AR also fosters inclusivity through features such as real-time language translation and adaptive visual content.

In addition to its immersive capabilities, AR strengthens what is often called digital agility-the capacity to engage effectively with evolving technologies and digital platforms. This competency is crucial for groups who have had limited exposure to digital environments and need to build confidence and fluency in navigating digital learning systems (Lu & Ramamurthy, 2011; Lee *et al.*, 2015). In this sense, AR contributes not only to content delivery but also to broader digital empowerment.

Immersive technologies such as virtual reality (VR) and mixed reality (MR) add another dimension to the Phygital Centre's approach. These tools enable learners to simulate complex tasks and professional scenarios in safe, controlled environments. From healthcare to logistics, immersive learning supports both technical skills and soft competencies such as decision-making and emotional regulation (Jung *et al.*, 2015; Kandemir *et al.*, 2024). When combined with in-person mentoring and peer learning, these experiences reinforce the hybrid model that defines the Centre.

Supporting this entire technological system is a semantic and cloud-based infrastructure that ensures interoperability, scalability, and real-time responsiveness. Natural Language Processing (NLP) plays a central role in organizing and simplifying learning content, extracting key concepts, and adapting materials to different linguistic and cognitive needs (Roll & Wylie, 2016). This functionality is particularly important for learners with low literacy levels or language barriers, who often require content mediation to access training opportunities meaningfully.

Altogether, the technologies embedded in the Phygital Centre form a coherent and socially oriented infrastructure. Rather than being used as ends in themselves, they function as integrated resources that support learning personalization, inclusion, and empowerment. By aligning technological innovation with educational accessibility, the Centre redefines how digital transformation can serve social impact.

4.1 Technological Infrastructure for Phygital Customization: Augmented Reality and Immersive Reality

The Phygital Center uses Artificial Intelligence (AI) to provide a personalized learning experience. AI algorithms process a massive number of data points (such as user interactions, performance metrics, and demographic data) to formulate personalized learning tracks for each student (Pironti, 2022). This ensures that the Phygital Hub can continuously adapt its educational content according to the evolving needs of its user base.

For instance, AMELIA (Advanced Multidimensional Environment for Learning, Innovation and Acceleration) - the Data Knowledge Platform Ecosystem which support the collection and processing of data for the GRINS Project - leverages AI to enhance accessibility for a diverse user base with varying levels of technical expertise. Its interface facilitates data visualization through interactive charts, maps, and dashboards, ensuring that information is easily interpretable. By generating customized reports and insights tailored to stakeholders such as small and medium-sized enterprises (SMEs), local administrations, and academic researchers, AMELIA facilitates evidence-based decision-making. This functionality is particularly critical in addressing fragmented and inconsistent data sources through advanced geo-referenced analytics, thereby enabling local governments to optimize resource allocation and design targeted interventions to reduce socio-economic disparities.

This ongoing customization is particularly useful for disadvantaged learners who may struggle more than others in some areas, but may also accelerate faster than others in other areas. The Phygital Centre, providing a customized learning experience, increases the chances that learners will stay motivated and finish their programs (Silvia *et al.*, 2023).

The application of AI in education is based on the theories of adaptive learning, which posits that educational content should be customized to each individual learner's needs and learning style. Not only does this enhance learner outcomes, it also increases the overall efficiency of the educational system as fewer resources are being wasted (Bini *et al.*, 2023).

Immersive Reality expands the spectrum of fully immersive digital experiences such as Virtual Reality, which simulates a real-world environment, and Mixed Reality (MR), which combines both real-world and digital elements. In immersive reality, the "real world" could be a bit hidden, because of full immersion in a digital environment. In contrast, immersive reality can bring the magic and immersive experience while exploring new landscapes, but phygital experience can bring interaction to interact in real time with the physical world. It is imperative to understand the difference between augmented reality and immersive reality, especially in areas that could benefit from these technologies to enhance learning and connectedness, such as health care, education and community events. As tech continues to develop at a break-neck pace, it becomes critical to understand the difference between augmented reality and immersive reality. These two technological catalysts lay the foundations for a "phygital" experience that blends the digital and physical realms in a fluid, engaging manner. Augmented reality is the superimposition of computer-generated images or information, such as data, onto the physical world. Smartphones or smart glasses, devices that enable the perception of these digital elements, facilitate the deployment of this technology. Augmented reality has been discussed as a technology primarily aimed at enhancing the real world experience through the addition of novel elements or details without compromising on essential authenticity (Kandemir *et al.* 2024).

This demands for robust technological infrastructure that can derive insights from data to increase the personalization of educational services and the data-dictionary assumes this role. It takes a data-driven approach to analyze data across a spectrum of different sources to provide educators with a holistic view of their learners' progress, needs, and preferences, allowing for ongoing optimization of content and delivery. Such information is especially useful within phygital environments, where in-the-moment content customization is essential to learner success. This level of personalization is particularly beneficial for additionally disadvantaged groups of young people, especially given their low levels of success in formal education systems (Mele *et al.*, 2023).

As the sensitive nature of data gathered from disadvantaged learners, it is very important to maintain security and privacy. It should be aligned with stringent data protection structures, like GDPR, and have high-end security mechanisms preventing data leak, ensuring privacy. This guarantees the platform is safe and reliable by utilizing encryption technologies, secure data storage solutions, and conducting regular security audits. Besides technical-security protections, the Phygital Hub will need to ensure that learners are fully aware of their data usage and have the right of control over their personal data. Such transparency is crucial to building trust with learners, especially those who come from disadvantaged backgrounds and are thus more susceptible to data exploitation (Silvia *et al.*, 2023).

4.2 Impact on Social Inclusion

The Phygital Hub is outlined as a transformative social inclusion model, targeted at overcoming the structural obstacles that prevent access to education, vocational training and entrepreneurship for disadvantaged communities as NEETs, immigrants, or inmates. The model integrates digital learning platforms with physical community hubs, thus providing a hybrid solution to offer both technology immersion and human interest exploration. NEETs receive agile, skill-based education, matching market requirements and increasing employability. It also offers tailored language, legal and

vocational programs for migrants to help their integration into both labor and society (Buzek & Scheuplein, 2022). Eventually, prisoners are able to attend virtual simulations, classes, and mentorships, which increases their chances of becoming acquitted once released from prison. Based on community engagement and using artificial intelligence (AI) to tailor the learning process to the individual learner, the Phygital Hub encompasses a myriad of initiatives: in addition to providing technical and entrepreneurial skills, it builds a sense of community and empowerment and shows promise as a replicable, scalable intervention for marginalized populations (Jones *et al.*, 2023).

5. GRINS Case Study: Successful Customization for Disadvantaged Groups

In GRINS, the innovative implementation of the Phygital Centre aims to promote social and economic inclusion of disadvantaged groups by integrating digital solutions with face-to-face involvements for customized re-skilling and up-skilling educational pathways for economic independence and social inclusion.

We recognize a significant gap within the province of Catania that seeks to cover social and educational struggles of marginalized people, through an entrepreneurial educational intervention model that is scalable and offers strong empirical evidence of positive impact. Several case studies demonstrate the success of customized phygital learning environments for disadvantaged groups. The project focuses on blending of digital content with in-person supports to give learners the ability to engage with educational resources at their own pace through mentorship.

Another interesting use of phygital tools is the one for training inmates in vocational programs. These programs use digital replicas of real world tasks that traditional behavioral entrepreneurism can help with and combine it with in-person workshops to get inmates the skills to re-enter society and the workforce post-release. This balanced approach of theory and application, within a spacious and accommodating environment, guarantees preparedness to join the workforce, as well as to face the challenges of reintegration (Mele *et al.*, 2023).

This Phygital Centre is structured around two key components (a) digital learning platforms and (b) physical community hubs to deliver personalized educational content to target audiences based on their individual needs and progress, as disadvantaged groups, including NEETs, migrants, inmates. The physical hubs, meanwhile, provide spaces for in-person mentorship, practical training, and peer-to-peer interaction.

It should be noted that Phygital Centre offers a comprehensive digital data dictionary based on a carefully organized collection of data sets classified in different categories. Consequently, target audiences identified above are able to receive and utilize personalized contents.

The use of AI in the Phygital Centre aligns with the broader theoretical principles of adaptive learning, which suggest that educational content should be tailored to the individual learner's needs and learning style. By offering a personalized learning experience, the project increases the likelihood that disadvantaged learners will remain engaged and complete their courses (Silvia *et al.*, 2023). Furthermore, the strongly based on AI customization contributes to create a tailored learning experience inside the Phygital Centre in terms of re-skilling and up-skilling, which is one of the key elements of the model of action designed and implemented to support and encourage the development of an entrepreneurial attitude to enhance social inclusion. The focus on NEETs, inmates, and migrants reflects the project's commitment to addressing the needs of some of the most marginalized groups in society.

By focusing on practical, vocational training, the Project ensures that learners are prepared with the skills necessary to thrive in the workforce. This benefits their individual outcomes, while also supporting the broader goal of creating a more inclusive, equitable society (Mele *et al.*, 2023).

GRINS Phygital Centre in Catania was intentionally designed as a scalable, replicable model that can be applied to other territorial contexts, especially those in which it is necessary to improve the entrepreneurial approach to accelerate socio-economic development. The available modules make the

project highly adaptable to varied societal and economic settings, presenting a national strategy to tactics addressing social and educational issues. By partnering with local governments, NGOs, and private enterprises, this Phygital Centre aims to expand its reach and impact, creating a network of Phygital centres that serve disadvantaged groups across the country.

Going into more detail, to effectively structure personalized learning paths based on the needs of the target categories, that is disadvantaged groups as NEETs, migrants, inmates, the Phygital Centre will equip itself with a software platform that will fulfill the functions of Data Dictionary with structured data from relational databases, semi-structured data from web pages, social media feeds, raw feed directly from a sensor source, geospatial, e-mail, etc., or unstructured data from video, images, audio, clicks. Data dictionary, in fact, is defined as a centralized repository containing details about the data, including its meaning, links to other data, origin, usage, and format. Data dictionaries are vital for various data management activities, such as facilitating data conversion, testing data generation, validating data, and documenting data usage criteria (Rashid *et al.*, 2020).

The platform (deep tech knowledge management system) required to support the work of the Phygital Centre in Catania should be capable of acquiring, delivering and distributing knowledge in SaaS (Software as a Service) mode in the cloud, respecting the requirements of scalability, security and interoperability between multiple devices (PCs, smartphones and tablets, etc.) and using advanced natural language processing (NLP) technologies. It must be able to acquire text documents of various formats and from various sources for the construction of the “data dictionary”.

It also must use NLP algorithms to perform operations for: the automatic identification and structuring of key concepts, entities, relations and topics; the automatic grouping of documents based on their semantic affinity; the addition of metadata and semantic links to increase the information value of the contents; the automatic transformation of complex contents into more understandable versions, maintaining semantic integrity; the information extraction, thematic clustering, semantic enrichment, simplification and advanced indexing to facilitate rapid and relevant searches.

This platform will perform a generative synthesis capable of automatically generating summaries of the acquired documents, with the possibility of customizing the desired level of detail and producing personalized textual contents based on specific requests. It will also provide a multimedia layer for the presentation of the contents and a user-experience that allows the matching between the acquired knowledge contained in the “data dictionary” and the user profile to offer an active, immersive and collaborative learning experience.

In such way, this digital platform represents the core of the Phygital Centre for training and empowerment through the personalized delivery of information contained in the “data dictionary” with respect to the specificities of the target and consistent with the physical and digital context of use. It provides user analysis for the identification of objective targets and clustering consistent with the reference context to ensure the customization of the activity provided by the platform also in light of the recognition of work skills for the creation of occupational profiles and job orientation through specific training and work paths.

Besides this, it provides a frontend for administrative use (admin console) that allows convenient editorial management of platform content, for uploading and adding textual information (e.g. captions, alt text, labels) and for managing the multimedia content creation service (video, animated presentations, podcasts, webinars). Such content and information must also be able to be managed via API services, drawing from a storage cluster and ensuring content management from external consoles.

Additional services provided by the platform will be a simultaneous translation tool to overcome language barriers; secure digital identities for undocumented people (e.g. migrants, homeless); a data dictionary query tool via chatbot; a digital user experience through the use of Virtual Reality (VR) and Augmented Reality (AR) solutions for the provision of interactive and gamification content, as well as the simulation of technical-manual activities, the creation of virtual and metaverse experiences with the creation of virtual spaces, virtual tutoring activities, emotional support and verification of learning progress with interactive quizzes and certification of achieved results.

5.1 Social and Economic Impact of the GRINS Phygital Centre

The main social impact of the GRINS Phygital Centre is the enhancement of educational and training opportunities for target groups. Through flexible learning paths on the Centre, socio-economic and other barriers to learning are diminished and such possibilities further help learners in the pursuit of quality of life. This is especially true for groups like NEETs, inmates, and migrants who have been traditionally excluded from conventional teaching settings (Schneider, 2021).

Besides that, this Phygital Centre contributes to improving the educational results, as well and greater social inclusion. The Centre reduces the social gap and promotes workplace education by equipping learners with the skills that are required to have confidence for joining the workforce. This is consistent with more inclusive social theories that suggest it is crucial for marginalised people to have access to and be woven into dominant economic and social systems (Silvia *et al.*, 2023).

It is well documented that socio-economic empowerment occurs most effectively when provided through education in entrepreneurship, as this approach is most beneficial to those most disadvantaged in society. The Phygital Centre opens a direct path to economic participation by training learners to create and manage their own businesses. Such business acumen is especially useful to NEETs and prisoners who may find it more difficult to identify traditional routes into employment, and instead can craft their own by embarking into entrepreneurship.

Additionally, the Phygital Centre's emphasis on Entrepreneurship Education ties directly into wider theories of economic development, which posits that encouraging innovation and entrepreneurship is a crucial means of driving local economy and creating employment opportunities (Nozdreva *et al.*, 2023). The Centre is contributing to long-term economic growth and stability by preparing underprivileged learners for success in the digital economy. Phygital education is not only beneficial to learners but long-term it benefits also the society since it also stimulates local economies, particularly in underserved areas, by increasing educational attainment and fostering entrepreneurship. Because of this, employment, income levels and overall economic stability tend to rise (Schneider, 2021).

Moreover, the Phygital Centre's focus on customization guarantees that the educational services offered align directly with the requirements of the local economy. The link between education and economic development is essential for the sustainable existence of both the Centre and the communities (Mele *et al.*, 2023).

To assess the impact of these interventions, the GRINS evaluation framework integrates a set of both qualitative and quantitative key performance indicators (KPIs). These go beyond traditional metrics to capture multidimensional outcomes. The Digital Skill Uplift Score (DSUS), based on the DigComp framework (Vuorikari *et al.*, 2016), measures improvements in learners' digital competencies across key dimensions such as content creation, data literacy, and online collaboration. The Organizational Learning Capacity Index (OLCI) evaluates the Centre's ability to incorporate feedback and adapt its educational strategies dynamically (Jerez-Gómez *et al.*, 2005). Additionally, the Stakeholder Participation Rate (SPR) tracks the involvement of external actors-such as NGOs, SMEs, and local authorities-in co-designing educational paths and delivering support services (Liu *et al.*, 2019).

These indicators serve a dual purpose: they enable continuous monitoring of learner progress and engagement, while also assessing the strength of the broader educational ecosystem and the effectiveness of cross-sector partnerships. In doing so, the GRINS Phygital Centre positions itself not only as a space for individual empowerment but as a platform for structural inclusion and shared innovation.

5.2 Challenges in implementing the Phygital Centre

Equitable access to technology is one of the key challenges while implementing the Phygital Centre. Many marginalized and disadvantaged groups within the population, especially those living

in rural or impoverished regions, lack access to the digital infrastructure needed to engage meaningfully in online learning. The Centre must collaborate with government agencies, NGOs, and private sector partners to develop low-cost or subsidized technology solutions to address this challenge (Mele *et al.*, 2023).

The long-term success of the Phygital Centre depends on effective stakeholder engagement and alignment with national policies. Maintaining robust collaboration with government agencies, private sector actors, educational institutions, and NGOs is imperative to ensure both financial sustainability and operational effectiveness (Nozdreva *et al.*, 2023).

Furthermore, continuous innovation is essential for the Centre to retain its relevance in an evolving digital landscape. As technological advancements reshape educational paradigms, the Phygital Centre must remain agile and responsive, continuously adapting its educational methodologies and service offerings to meet emerging needs. By adopting an iterative and data-driven approach to program development, the Phygital Centre can reinforce its position as a leading model for digital education, social inclusion, and workforce integration (Mele *et al.*, 2023).

6. Propositions and expected results

The model utilizes customization enabled by AI and community-based learning spaces, providing a scalable and adaptable framework for empowering disadvantaged individuals. While Phygital Centre serves as an initial case study, its successful implementation may provide insights into the replication of the model in other regions.

Phygital Centre serves as a tangible example of how the theoretical principles discussed in this article can be applied in practice to foster social inclusion and educational equity. By combining digital accessibility with physical engagement, the project offers a pathway to reintegration for some of the most vulnerable members of society. This hybrid interaction model establishes the foundation for the dissolution of the numerous communication barriers that affect the project's target groups, including NEETs and other disadvantaged groups, to varying degrees and with distinct characteristics. In short, GRINS helps build a strong and sustainable knowledge ecosystem in Italy.

The platform plays an indispensable role in fostering resilience and inclusiveness, facilitating the development of quantitative, data-driven approaches in a field, namely the socio-economic field, which has heretofore been primarily governed by qualitative sources.

As it expands, Phygital Centre will demonstrate its scalability, offering a blueprint for other cities seeking to address similar social and educational challenges.

Moreover, the establishment of the Phygital Centre demonstrates GRINS's dedication to developing tangible instruments for inclusiveness by providing pathways for previously marginalized individuals to gain the competencies required for integration into the labor market, thus facilitating the process of cohesive and inclusive development within our country.

To perform these objectives, working on Entrepreneurial Education in the Phygital Centre, three propositions will be verified, arising from the previous discussion:

1. AI-driven customized learning paths, in Entrepreneurial Education, are more effective in increasing knowledge and skills of target audiences.
2. Customized Entrepreneurial Education in a Phygital Centre, supported by AI, Augmented Reality and Immersive Reality, increases entrepreneurship attitudes in target audiences.
3. The more the entrepreneurial attitudes of disadvantage groups, the more their economic independence and social inclusion.

Assessing such propositions, Phygital Centre could be identified as a significant contributor to the mitigation of disparities, faced by numerous marginalized individuals. The hybrid nature of the Phygital Centre can ensure that learners acquire not only theoretical knowledge but also develop practical skills, and above all, an entrepreneurial attitude, essential for successful entry into the job market.

The dual-channel approach enhances employability, particularly for those who may not thrive in conventional educational settings (Nguyen *et al.*, 2021). By facilitating collaborations with the Grins Project, the Centre also ensures that training aligns with labor market demands, creating clear pathways to employment and entrepreneurial opportunities. Beyond employment, the Phygital Centre fosters economic independence through "entrepreneurial attitude education". By integrating business training, it empowers learners to develop projects, manage finances, and navigate the complexities of the market. From a policy perspective, the Phygital Centre offers a scalable and adaptable model that can be tailored to various regional and socio-economic contexts. Its flexibility allows policymakers to implement targeted interventions that directly address local labor market conditions and educational needs.

7. Conclusions, limitations and managerial/policy implications

This study presents a conceptual and practice-oriented reflection on the Phygital Centre developed within the GRINS project, emphasizing its potential to foster social inclusion and economic empowerment among marginalized populations. While the Centre offers an innovative blueprint for hybrid, AI-enabled entrepreneurial education, it remains in its developmental phase, with full implementation expected by 2025. As such, this contribution draws from theoretical models and project documentation rather than empirical data. Future research should focus on longitudinal evaluations of the Centre's impact, including learner outcomes, labor market integration, and replicability across diverse socio-economic and cultural contexts.

The Phygital Centre goes beyond the scope of traditional educational initiatives, positioning itself as a strategic enabler of inclusive growth. By integrating AI-driven customization with community-based learning and multistakeholder partnerships, it introduces a dynamic and context-aware educational infrastructure. This infrastructure is designed to address structural inequalities while enhancing local capacity for innovation and entrepreneurship. Its success, however, relies on effective governance, continuous technological renewal, and policy frameworks that support flexible, hybrid learning systems.

From a managerial perspective, the implementation of the Centre requires a responsive approach to stakeholder engagement, service innovation, and infrastructure development. This includes the establishment of robust collaborations among governmental bodies, educational institutions, civil society organizations, and private sector actors. Operational agility is essential: the Centre must continuously adapt to emerging digital technologies and shifting labor market demands while ensuring accessibility for users with varied levels of digital proficiency.

Ensuring the sustainability of the Phygital Centre also entails maintaining a secure and interoperable digital infrastructure, compliant with data protection regulations such as the General Data Protection Regulation (GDPR). Attention must be given to the user experience, particularly in the design of inclusive and intuitive interfaces that enable meaningful participation. Accessibility via mobile devices and multilingual functionalities are further levers for reducing digital exclusion.

To sustain long-term growth, the Phygital Centre must adopt an agile and scalable operational model (Nguyen *et al.*, 2021). Achieving this will require a careful balance between online and offline learning, allowing learners to transition seamlessly between digital courses and physical mentorship sessions. It is imperative to evaluate success beyond traditional performance indicators. While completion rates and employment outcomes are valuable metrics, assessing the economic and social impact of entrepreneurial initiatives developed through the Centre is equally crucial.

The latter evaluation will also be fundamental with respect to the pursuit of the third mission strategic objectives in the perspective of the Entrepreneurial University and its impact on the entrepreneurial ecosystem to empirically analyze the effectiveness of such connections.

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