EDUCATIONAL TECHNOLOGIES AND INCLUSION IN NON-FORMAL LEARNING ENVIRONMENTS
TECNOLOGIE EDUCATIVE ED INCLUSIONE IN AMBIENTI DI APPRENDIMENTO NON FORMALI

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ABSTRACT

The study explores the integration of educational technologies in non-formal learning environments. Although ETs are used in school settings, their application in natural environments presents unique challenges and opportunities, offering a bridge between theoretical knowledge and direct experience. We examined several case studies in Italy, including nature trails guided by apps, the use of augmented reality, and gamification applications for discovering the local area.

Lo studio esplora l'integrazione delle tecnologie educative in ambienti di apprendimento non formali. Sebbene le TE siano utilizzate in contesti scolastici, la loro applicazione in ambienti naturali presenta sfide e opportunità uniche, offrendo un ponte tra la conoscenza teorica e l'esperienza diretta. Abbiamo esaminato diversi casi studio in Italia, tra cui percorsi naturalistici guidati da app, l'uso di realtà aumentata e applicazioni di gamification per la scoperta del territorio.

KEYWORDS

Educational Technologies, Natural Contexts, Applications, AR, Gamification.
Tecnologie Educative, Contesti Naturali,Applicazioni, Realtà Aumentata, Gamificazione

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Introduction

The use of educational technologies in natural environments is based on various pedagogical and psychological theories that emphasise the importance of context, interaction and direct experience for meaningful learning. The situated learning approach argues that knowledge is not an abstract entity, but is intrinsically linked to the context in which it is learned and used. In a natural environment, the use of technologies such as plant identification apps or augmented reality to explore the history of a place allows information to be anchored to a real and tangible context. This fits perfectly with social constructivism (Vygotsky), according to which learning is an active process of knowledge construction through interaction with the environment and with others. Technologies facilitate collaboration and the sharing of discoveries, transforming an excursion into a true collaborative learning experience. The analysis of the integration of educational technologies (ET) in non-formal contexts, such as parks, museums and nature reserves in Italy, requires a preliminary examination of the conceptual and regulatory framework that defines its contours. This process of technological adoption is part of a specific pedagogical and institutional context, characterised by distinctive teaching principles and growing political recognition. The pedagogy of reference, particularly for adults, is andragogy, which conceives the learner as a person aware of their own knowledge needs, intrinsically motivated to learn and capable of self-direction in the learning process. Education in these contexts is not a mere transfer of information, but a circular process that actively involves both the educator and the learner. The educational technologies analysed in this report, with their interactive and gamification features, act as catalysts for this approach, transforming the simple consumption of content into an experience of active exploration and problem solving, a fundamental shift from the role of passive observer to that of protagonist of one's own learning.

Theoretical framework

Urie Bronfenbrenner, a developmental psychologist of Russian origin who moved to the United States at the age of six, proposed a paradigmatic view that profoundly redefined developmental psychology. His central postulate is that human development does not occur in isolation, but is the result of a dynamic and reciprocal interaction between a developing individual and the multiple environmental systems that surround them. This perspective represented a conceptual “collision” with pre-existing psychology, which tended to focus almost exclusively on the intrinsic characteristics of the individual, treating the environment as a static structure or, in the worst case, completely neglecting the

influences of broader social contexts. Bronfenbrenner harshly criticised the experimental research methods used in laboratories, which were the scientific standard at the time. He argued that observing children's behaviour in 'unfamiliar, artificial, short-lived contexts with unfamiliar adults' produced results related to 'unusual' behaviour and, therefore, could not be generalised to real life. An investigation limited to the immediate situation of the subject, which ignored the impact of other contexts and inter-systemic relationships, was unable to capture the complexity of development. This narrow methodological approach failed to observe the reciprocal interactions between variables and the broader environmental forces that shape an individual's growth. Bronfenbrenner's criticism transcended simple methodological preference, constituting a profound epistemological challenge. He argued that a true understanding of development required the study of the subject in their 'natural life space'. The goal of research, according to his vision, should not be the manipulation of isolated variables to test a hypothesis, but rather the understanding of the complex interactions that occur spontaneously. This principle, which he called “ecological validity”, became the foundation for both his theoretical architecture and a new research approach, in stark contrast to the “confirmatory” methodologies of his time. To illustrate his complex theory, Bronfenbrenner introduced the metaphor of Russian dolls, or Matryoshka. According to this model, an individual's ecological environment is conceived as a series of concentric structures, each nested within the other, which exert a progressive and interconnected influence on the person at the centre. His thinking, however, did not remain static but continued to evolve, culminating in the more mature and sophisticated Bioecological Model, which integrated new and crucial elements. Bronfenbrenner (Breckenridge, 2016) defined development as 'that process through which the growing individual acquires a more extensive, differentiated and valid conception of the ecological environment, and becomes motivated and capable of engaging in activities that lead him or her to discover the characteristics of that environment, and to accept or restructure it, at levels of complexity that are analogous or greater, both in form and content'.[1] This definition radically shifts the focus from the individual as a mere passive receiver of environmental stimuli to a dynamic and active entity. Contrary to the view of the individual as a passive *tabula rasa* shaped by their environment, Bronfenbrenner argues that the person is an agent of change who actively contributes to restructuring the context in which they live. It follows that the relationship between the individual and the environment is inherently characterised by reciprocity. Influences are not unidirectional, but bidirectional: a child is not simply influenced by their parents or school, but in turn influences their actions and dynamics.

[1] See U. Bronfenbrenner, Ecology of Human Development, Italian translation, Il Mulino, Bologna 1986

Another fundamental concept is that of “ecological transition”, which occurs whenever an individual moves to a new environment or takes on a new role. Examples of such transitions include starting school, parental divorce, or the birth of a sibling. These transitions are considered a function of both biological and environmental changes, and testify to the continuous process of adaptation between the organism and its context. Each transition is both a consequence of previous development and a cause of new development, marking a crucial moment in the individual's growth path. Bronfenbrenner's original model, Ecological Systems Theory (Guy, 2004) articulates the developmental environment in a series of nested and interconnected structures. Their influence is complex and interdependent, with each system shaping and being shaped by the others. The microsystem represents the level closest and most immediate to the individual. It is the environment in which the person has direct experience and where face-to-face interactions take place, such as the family, school, peer group and neighbourhood. Bronfenbrenner defines each environmental situation within a microsystem through three key elements: molar activities (meaningful, purposeful actions, such as playing or reading), relationships (interpersonal bonds, such as those between parent and child or between classmates), and roles (expected behaviours and social positions). Relationships within this system are bidirectional: a parent influences their child and, in turn, is influenced by them. The mesosystem is the “system of microsystems”, which refers to the interconnections and interrelationships between two or more microsystems in which the developing individual actively participates. Microsystems do not operate in isolation, but influence each other. A classic example is the relationship between the family and the school. Smooth communication and active participation by parents in their child's school life can significantly improve their academic performance and development. The exosystem consists of one or more environmental situations in which the individual does not participate directly, but in which events occur that indirectly influence their immediate living environment. A paradigmatic example is the parents' workplace. Company policy on flexible working hours or a parent's work stress can influence the quantity and quality of time spent with the child, with direct consequences on their emotional development and family relationships. The macrosystem represents the broader context that contains all other systems and influences their functioning. It consists of cultural ideologies, values, social norms, laws and beliefs that are passed down from generation to generation. For example, a culture that values individualism can influence parenting styles in the microsystem, encouraging children to be more competitive and self-sufficient. The chronosystem, added later to the original theory, introduces the time factor, recognising that development is a dynamic process that takes place over time. This system includes both important transitions that occur in an individual's life (e.g., moving house, parental divorce) and large-scale historical and social changes (e.g.,

pandemics, wars, the advent of the internet). Bronfenbrenner's theory, with its nested systems structure, demonstrates how a change in one system can have a cascading effect on others, even indirectly. A global economic crisis (macrosystem) can lead to corporate downsizing policies (exosystem), which in turn increase stress in the family (microsystem) and negatively affect school-family interactions (mesosystem). The evocative image of the 'butterfly effect' clarifies this concept: the imperceptible movement of a butterfly's wings does not directly cause a cyclone, but it can trigger a series of chain reactions in the atmosphere that, over time, can lead to a grandiose and devastating outcome. This illustrates the essence of the theory: not the mere presence of systems, but their dynamic and interdependent interaction. Throughout his career, Bronfenbrenner's thinking evolved in response to criticism, particularly that which lamented a lack of emphasis on biological and cognitive factors in favour of the environmental context. Recognising these limitations, Bronfenbrenner revised and refined his theory, renaming it the 'bioecological model'. This evolution integrated the intrinsic characteristics of the individual, making the theory more comprehensive and robust. The mature bioecological model is known as the PPCT (Process-Person-Context-Time) model, which highlights the synergy and interdependence of four key elements that drive development. Process: At the centre of this model are proximal processes, considered the true “engine of human development”. These are defined as complex, lasting, reciprocal interactions between an active, evolving human organism and the people, objects and symbols in its immediate environment. Examples include playing with other children, reading a book with a parent, or exploring the world. The power of these processes varies systematically depending on the characteristics of the person and the context in which they occur. This shift from a focus on systems to a focus on proximal processes is at the heart of the transition. While systems describe *where* development occurs, proximal processes explain *how* it occurs. The theory does not claim that the family (microsystem) causes development, but that the proximal processes that occur within it (e.g., daily dialogue, emotional support) are the real mechanisms of promotion. Person: This element recognises the role of the individual's personal characteristics that influence proximal processes. These characteristics are divided into three categories: demand characteristics (e.g., age, gender, physical appearance), resource characteristics (e.g., intelligence, skills, access to education), and strength characteristics (e.g., motivation, persistence, temperament).

Context: The context in the bioecological model reflects the structure of the nested systems (microsystem, mesosystem, exosystem, macrosystem) described above, considering them as the framework in which proximal processes manifest themselves. Time: This element, already present as a chronosystem, is divided into three dimensions: micro-time (the continuity of an activity at a specific moment), meso-time (the regularity with which proximal processes occur, e.g. on a daily or

weekly basis) and macro-time (the chronosystem, which focuses on large-scale historical and cultural changes). The strength of the PPCT model lies in its ability to capture the dynamic and synergistic nature of development, demonstrating that the characteristics of the person, context and time do not act independently, but interact to shape the effectiveness of proximal processes. Bronfenbrenner's theory is in constant dialogue with other influential models of developmental psychology, highlighting its unique features and distinctive contribution. A fundamental difference between Bronfenbrenner and Jean Piaget lies in the nature of development. Piaget's theory is considered discontinuous in that it posits that cognitive development occurs in a succession of distinct stages (sensory-motor, preoperational, concrete and formal), with learning manifesting itself in specific stages. In contrast, Bronfenbrenner's theory is seen as continuous, as the individual is constantly influenced by ecological factors that drive continuous learning. Furthermore, while Piaget focused primarily on the physiological growth and cognitive development of the individual, Bronfenbrenner emphasised the fundamental and multidimensional role of the environment. Bronfenbrenner and Lev Vygotsky are often compared, as both revolutionised the understanding of development by emphasising the importance of context and social environment. Both theories view development as a continuous process, influenced by sociocultural interactions. However, the differences in their approaches are significant. Vygotsky introduced the concept of the Zone of Proximal Development (ZPD), focusing on the role of mediation by a more competent adult or peer in promoting learning. Bronfenbrenner, while recognising social influence, broadened the perspective to include an entire "ecology" of interconnected systems that go far beyond direct interaction, providing a more holistic and complex framework. His theory has a greater impact on intentional learning because, by recognising the dynamic nature of the process, it provides a framework for creating inclusive environments that actively support development.

Table 1: Comparison of theories

Comparison Criteria	**Bronfenbrenner's theory**	**Piaget's theory**	**Vygotsky's theory**
Nature of Development	Continuous	Discontinuous (in stages)	Continuous

Comparison Criteria	Bronfenbrenner's theory	Piaget's theory	Vygotsky's theory
Main focus	Environmental factors and their interconnection	Cognitive and physiological development	Sociocultural factors and interactions
Key Concepts	Ecological Systems, Proximal Processes	Stages of development	Zone of Proximal Development, Social Mediation
Role of the environment	Essential, multidimensional, dynamic	Stimulating role in the transition between stages	Role as potential source and mediator of development

Bronfenbrenner's theory has been acclaimed for its holistic and systemic nature. By offering a dynamic and interconnected model, it has provided a powerful tool for understanding that development is not a linear process, but the result of a complex interaction between the individual and their environment. Its relevance is evident in its ability to provide a useful framework for designing research and interventions that are not limited to the individual but consider the entire developmental ecosystem. Despite its merits, the original theory has received criticism, mainly from cognitive-behavioural currents. The main criticism was the initial lack of emphasis on biological and cognitive factors in individual development, as well as the absence of a succession of phases or stages, unlike Piaget's model. Bronfenbrenner's response to these criticisms was not defensive, but proactive and intellectually honest. Recognising the limitations of his original theory, he radically revised it to include biology (hence the “Bio” in the model's name) and the central role of the person. This evolution, culminating in the PPCT model, demonstrates that his work was a “science of progress” in continuous adaptation, capable of integrating new elements to maintain its validity and relevance. The fact that Bronfenbrenner himself raised doubts about the 'falsifiability' of his model is not a weakness, but an expression of his profound methodological awareness, which has

prompted the scientific community to develop new research approaches more suited to the complexity of real life.

Despite its conceptual validity, the theory has empirical limitations. Its extreme complexity, given the interconnected and synergistic nature of the systems, makes it difficult to test rigorously. Studies applying the ecological model can establish the existence of an effect, but they cannot prove direct causality, as it is almost impossible to isolate and manipulate the infinite variables at play. Another potential limitation is the risk of stereotyping: the theory could lead to the assumption of a lack of development in individuals who do not have 'strong and positive' ecological systems, ignoring the fact that many people manage to develop in a balanced and resilient way despite the difficulties of their environment.

Bronfenbrenner's Ecological Theory is not simply a theoretical model, but a practical tool that has found application in a variety of fields, from psychology to education and social policy. The ecological approach encourages educators to consider the student's entire life context, not just their individual abilities or behaviour in the classroom. A teacher who notices a student in difficulty can investigate external factors such as family tensions (microsystem) or problems in the neighbourhood (exosystem). The theory suggests building bridges between different contexts, for example through regular meetings between parents and teachers, to strengthen support for the child's learning and improve their performance. The theory has also found application in the design of adult education programmes that take into account the work and family needs of participants, offering flexible schedules or childcare services to facilitate participation. The theory provides a framework for the development of social programmes that respond to people's needs within their family and community relationships. It has a direct impact on the formulation of public policies, suggesting that to be effective, they must consider the various levels of influence. For example, a policy for child welfare must take into account how it affects not only families (microsystem) but also communities (mesosystem). Community projects aimed at reducing youth crime, for example, should not be limited to working with individuals but should also address external factors such as unemployment (exosystem) or a culture of violence (macrosystem).

Bronfenbrenner co-founded the Head Start programme in the United States, an initiative aimed at preschool children from low-income families. This programme represents a practical, large-scale application of his theory, as it provides a network of integrated services — educational, health and social support — that act simultaneously on multiple levels of the child's ecological system. By intervening not only with the child (microsystem), but also with parents, the community and

the policies that affect them, Head Start embodies the holistic and systemic approach advocated by Bronfenbrenner.

Urie Bronfenbrenner's legacy is to have transformed developmental psychology from a reductionist discipline, focused on isolated causes and relationships, to a holistic and contextual science that recognises the complexity of human life. His work is not a static theory, but a dynamic and adaptable framework that continues to inform research and intervention.

His theory remains crucially important in the 21st century. The model is flexible enough to integrate new phenomena such as the impact of technology. The advent of social media and the internet has created new "virtual microsystems" that influence peer interactions, access to information and the cognitive development of young people, demonstrating the continued relevance of the model. Furthermore, the ecological approach connects naturally with more recent models, such as the "bio-psycho-socio-environmental" model, which explicitly recognises the direct impact of the physical environment (e.g., pollution, green spaces) on human health and well-being, an idea that Bronfenbrenner had already intuited. The enduring strength of Ecological Theory and its bioecological model lies in its ability to capture the complexity of human development, providing an analytical lens that goes beyond the individual to embrace the entire "ecosystem" in which life unfolds. This holistic and interconnected view has not only changed the way science studies development, but continues to guide those working to improve the well-being of individuals and communities, recognising that humans are not isolated entities, but the product of their complex and reciprocal interactions with the surrounding world. (Capurso, 2008)

Educational Technologies in Italy

Non-formal learning is defined as an intentional process undertaken by individuals outside structured education and training systems, which takes place in environments with educational purposes, such as voluntary associations, businesses or, in the context of this analysis, museums and nature parks.[2] This type of learning is distinguished by its voluntary nature and focus on learning itself, rather than on obtaining a formal qualification or certification. It takes place in a variety of ways, including independent study, participation in conferences, direct experimentation and the exchange of ideas with experts. Although non-formal learning takes place in contexts free from academic constraints, the Italian system has developed a structured process for its validation. This is the process of

[2] http://www.project-musa.eu/wp-content/uploads/2020/10/R3.3-Digital-Interactive-Experience-Developer_Handbook_IT.pdf

Identification, Validation and Certification of Competences (IVC), a mechanism that aims to recognise skills acquired outside traditional school pathways. This process is linked to a National Register of Professional Profiles, which is the benchmark for training objectives, demonstrating a strong institutional orientation towards formalising and standardising even the most organic educational experiences. This tension between the inherently flexible and voluntary nature of non-formal learning and the system's need to measure and certify it is a crucially important element that guides the development and implementation of educational technologies in these environments. (Frezza, 2008)

TE projects can be designed to support experiential learning in a free manner, or to create structured pathways that, while taking place in informal contexts, can be easily documented and recognised at an institutional level. The strategic context in which the integration of technology into Italian cultural heritage is taking place is deeply influenced by the National Recovery and Resilience Plan (PNRR). This plan represents a significant source of funding, with specific calls for proposals, managed by bodies such as Invitalia, aimed at the digitisation of cultural heritage (invitalia.it). Examples of such initiatives include tenders for the digitisation of graphic works and museum objects, with an investment of €18.6 million. Regional administrations, such as the Marche and Lazio regions, have also promoted calls for tenders for the research and development of technologies to support cultural enhancement. (regione.marche.it).

However, there is a potential misalignment between the primary investment strategy and the most innovative applications. Much of the state funding seems to be focused on the digitisation of static assets, such as the inventory and cataloguing of collections, with the aim of making cultural heritage accessible in the form of a digital repository. (PNRR 2022) The exploration of parks and nature reserves in Italy is increasingly mediated by digital tools that enrich the experience. A virtuous example is *Visit Naturitalia,* an official application of the Ministry of the Environment and Energy Security, funded by PNRR funds for the digitisation of protected areas. This app offers verified information, offline maps and details on routes, flora and fauna. In contrast to this institutional approach geared towards the creation of official digital archives and guides, the following analysis will highlight how local initiatives and private platforms are instead exploring dynamic and interactive models, shifting the focus from mere consultation to the creation of immersive and participatory experiences. (mase.gov.it).

GPS technology, widely used for navigation, can be used creatively for educational purposes that go beyond simple utility. The *Sentieri Parlanti* (Talking Trails) project is a clear example of this, demonstrating how a simple walk can be transformed into an immersive learning experience. The app uses GPS coordinates to activate audio guides at specific points along the route.(Zamberlan.com) By listening to stories about “Where you are and where you can go”, “History and signs of man”,

and “Geology and landscape”, visitors do not simply follow a route, but interpret it, connecting what they see in the landscape with cultural and historical information provided in real time.(sentieriparlnti.caiveneto.it) This approach transforms the trail from a mere journey into a text to be read and listened to, enhancing the silence of nature with knowledge of the context. The application, created for safety in the environment, offers georeferenced routes with audio guides that enrich the physical experience with a strong narrative and informative layer on the history, geology and culture of the area. This project demonstrates that the added value of an ET in a natural environment is not only its orientation functionality, but its ability to transform a walk into an educational experience enriched by a narrative plot and curated content. To explore the integration of educational technologies (ET) in non-formal learning environments in Italy, a qualitative analysis was used that combined direct observation with digital data analysis.

Table 2: Comparative summary of the two models

These contexts, such as parks, museums and nature reserves, offer unique potential to enrich learning, transforming the visit from a simple passive experience into a dynamic and engaging interaction. The aim was to examine how TEs can enhance experiential learning by encouraging curiosity and independent discovery.

Qualitative research is based on two main pillars: one is Participatory Observation, a method that involves the active participation of the researcher within the learning

Developme nt Developme nt	**Project Exemplary**	**Source of Funding**	**Focus of Experience**	**Data Evaluation Available**
Institutional	*VISIT* *NATURAIT ALIA*	PNRR/Pu blic	Security, planning, verified information	Download data and reviews
Specific Project	*Talking Trails*	Specific initiatives Specific	Narration, cultural and historical content	Qualitative data from reviews

experience. For example, one can walk along a path in a nature park using an

interactive app, observing users' behaviour, their reactions and group dynamics. The focus is on how people interact with technology, whether they consider it an aid or a distraction, and how technology mediates their relationship with their surroundings. The second is Digital Data Analysis, which examines data such as the number of downloads of an app, average usage time, the most popular routes and the most visited sections. Analysis of feedback, reviews and comments on social media provides further clues about the popularity and effectiveness of the app. By cross-referencing this data with direct observations, a more complete picture can be obtained. Many Italian parks, such as the Gran Paradiso National Park, have developed apps that serve as virtual guides.

These apps offer geolocated routes, information on flora and fauna, interactive quizzes and points of interest. Qualitative analysis (Oddo et al., 2024), shows that users appreciate the opportunity to explore independently, but often the most meaningful interactions occur when technology stimulates reflection or discussion with fellow travellers. Analysis of digital data can reveal which trails are most popular or where users linger the longest. In some botanical gardens or nature reserves, *augmented reality* applications are used that allow users to point their smartphone camera at a plant to receive detailed information, such as its scientific name, properties and interesting facts. This technology transforms an otherwise static activity into an interactive experience. Observation has revealed that the use of AR increases engagement and information retention, especially among younger people. The *Vivarium* project in Campsirago, on Monte di Brianza, represents a more artistic and narrative application of AR.

In this case, the technology is used to “read the invisible”, superimposing nine *site-specific* augmented reality installations and a sound dramaturgy onto the landscape. The experience, accessible via the *ImaginAR* app, transforms the physical journey into a transmedia journey that engages all the senses of the audience, intertwining nature with elements of mathematics, mythology and digital art. The value of this project lies not in its utility, but in its ability to evoke a hybrid perception of the landscape, creating an emotional and intellectual connection with the territory that goes beyond simple observation.

The concept of *gamification,* i.e. the application of game elements to non-playful contexts, is widespread. One example is the use of multi-stage trails, quizzes or digital “treasure hunts” to explore historic centres or natural areas. For example, apps such as “Passeggiate nella Storia” (Walks through History) offer virtual challenges and rewards for completing trails in cities of art. *Geocaching* is a digital evolution of treasure hunting, combining the adventure of searching with the discovery of new places through the use of GPS. With over 30,000 *geocaches* hidden in Italy, often near monuments, historic buildings or scenic spots, *geocaching* is a hybrid pedagogical model that encourages users to explore actively and with motivation. This approach perfectly integrates physical activity and digital

navigation with the implicit learning of historical and geographical knowledge. The Italian experiences examined confirm the effectiveness of *geocaching* as a tool for cultural promotion and non-formal learning. Projects such as the *Val di Zena Geotrail* or the *Frignano Gotrail* demonstrate how gamification can be a vehicle for discovering little-known valleys and sites.

This model is particularly advantageous for small organisations or local administrations, which can take advantage of an existing platform with an established global community, avoiding the costs and complexities of developing a proprietary app. For families, *geocaching* is a tool that promotes teamwork and critical thinking. Furthermore, a quantitative analysis conducted on 80 applications and video games for museums in Italy revealed a fragmented but vibrant geographical and institutional landscape. Most initiatives (61.25%) are concentrated in Northern Italy, with cities such as Milan, Turin and Trieste leading the way.

This geographical distribution is not surprising, but it is important to note that almost 70% of the projects surveyed belong to non-state institutions, despite strong public sector involvement in their management. This suggests that innovation in this field is often driven by smaller, more agile entities operating outside the more established bureaucratic structures. Another relevant observation concerns the distribution of actively promoted initiatives, with southern Italy accounting for 50% of the projects examined. This data shows that, although development is more concentrated in the north, the south is strategically investing in the promotion of gamified experiences to enhance its heritage, recognising the potential of this approach to attract new audiences. The initial results of specific projects, such as a gamified museum network, indicate that gamification is not just a marketing strategy, but an effective means of changing visitor behaviour: over 5% of participants visited more than five museums, and over 70% expressed a desire to see similar systems in the future.(gameification.com) This demonstrates that gamification has the potential to encourage deeper and more lasting engagement with cultural heritage, transforming the visit from an isolated event into an ongoing journey of discovery.

Conclusions

Analysis of the integration of educational technologies in non-formal learning environments in Italy reveals a dynamic and varied landscape, characterised by promising trends and ongoing challenges. Educational technologies in Italy are evolving from simple utilitarian tools to powerful mediators of narrative and sensory experiences. There is a shift from the passive consultation model, embodied by cataloguing-only apps, to a model of interaction and creation, in

which the user becomes an active protagonist in the learning process. The adoption of platforms rather than individual *ad hoc* applications is democratising access to gamification and Augmented Reality, allowing smaller institutions to create their own experiences in a scalable way. However, some critical issues remain. There is a disconnect between the main institutional strategy, focused on the digitisation of static assets (e.g. museum collections and archives), and the innovative practices that are emerging at the local level, geared towards the creation of dynamic experiences. The geographical distribution and institutional nature of the projects show a strong imbalance, with innovation largely driven by non-state actors, suggesting a need for greater synergy between central policies and initiatives in the field. Finally, there is a lack of a holistic and standardised evaluation framework that integrates quantitative data on attendance with a qualitative understanding of the pedagogical impact. Success factors identified include designing user-centred experiences, integrating technology into a compelling narrative, empowering users as co-creators, and leveraging existing platforms and communities to scale projects. Ongoing challenges include the need to secure long-term funding beyond one-off grants, the training of professionals specialised in digital project management, and the development of robust evaluation methodologies that can measure educational effectiveness in non-traditional ways. The results indicate that the use of ET in natural contexts significantly increases participants' motivation and engagement, making learning more dynamic and interactive. The integration of playful and multimedia elements has fostered a greater understanding of complex concepts and promoted a deeper connection with the surrounding environment. The use of mobile devices also facilitated access to real-time information and allowed for personalisation of the learning experience. This study demonstrates that the strategic use of educational technologies can greatly enrich learning in natural settings, transforming simple observation into a guided and interactive discovery experience. Although challenges related to connectivity and access to equipment remain, the potential of these applications is immense for environmental and science education. The integration of ET offers numerous advantages, first and foremost the personalisation of learning**.** ET allows each user to proceed at their own pace and according to their own interests, transforming learning from passive to active, making it more stimulating. It makes information easily accessible and immediate. However, there are also challenges, as over-reliance on technology can distract attention from the real environment and, realistically, not everyone has access to devices or a stable internet connection, creating inequalities. Furthermore, the development and maintenance of these platforms require significant investment. Qualitative analysis of the integration of ETs into non-formal learning environments in Italy shows that these technologies can significantly enrich the experience. Qualitative analysis has shown that gamification stimulates competition and collaboration, making learning a fun and

social activity. The use of gamification as a tool to attract and engage audiences in the cultural and natural sectors is a growing trend. However, their success does not depend solely on the technology itself, but on how it is designed and integrated into the real context. Effective design should aim to complement and enhance the sensory and physical experience, rather than replace it. The future of education in these contexts lies in a harmonious balance between the digital world and the beauty of the natural world. Although platforms offer an effective model, their community-based nature raises issues related to safety and privacy, particularly for minors, and requires informed supervision. This model moves away from the rigid sequences of formal education and offers students the opportunity to discover, modify and share content in a way that they find personally meaningful. The pedagogical impact of such an experience is significantly greater than that of simple consumption, as it promotes the development of transversal skills such as *storytelling*, creative writing and the conscious use of technology, reversing the role of the learner from spectator to protagonist. Finally, we have seen how a wide range of applications in non-formal learning environments are offered by Augmented Reality, a sort of bridge between the physical world and an additional level of digital information. Its functionalities can range from simple utilitarian tools to complex narrative experiences. It is hoped that in the future, the focus will be on developing reusable platforms and frameworks that allow multiple organisations to create their own content, rather than investing in unique and expensive solutions. The priority is to integrate narrative and interaction into the experience, going beyond simple utilitarian functionality. It is also essential that evaluation metrics are integrated from the early stages of design in order to collect meaningful data on user engagement. Institutions could explore collaborations with local communities and schools to co-create content, as demonstrated in the case of *NutriMenti*. Before commissioning the development of a proprietary app, institutions should consider leveraging existing, established platforms, such as *geocaching*, which offer a ready-made audience and infrastructure at a low cost. It is crucial that the evaluation of a project's success is not limited to the number of downloads, but includes qualitative surveys on the user experience. Future funding opportunities could be directed towards dynamic and experiential projects that encourage the creation of interactive content, alongside the digitisation of static heritage. The establishment of a national framework for assessing the educational and cultural impact of TE in non-formal contexts could provide valuable guidance for future development. Finally, it is essential to promote greater collaboration between the public sector, non-state institutions and private developers to create a more cohesive and innovative ecosystem.

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