THE PEDAGOGY OF TINKERING: "CONSTRUCTIONS" FOR STEAMS WITH LEGO® BRICKS

LA PEDAGOGIA DEL TINKERING: "COSTRUZIONI" PER STEAM CON I MATTONCINI LEGO®

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ABSTRACT
Tinkering is a pedagogical approach that promotes learning through exploration, experimentation and creativity. Based on the idea of Creative Thinking, it enables students to develop critical and creative thinking by solving problems intuitively and iteratively. An emblematic example of this methodology is the use of LEGO® bricks, versatile tools that allow students to build, disassemble and rework ideas in a continuous process of discovery and innovation. LEGO® bricks, placed in an educational context, foster the development of STEAM skills and encourage collaboration, resilience and problem-solving. The present study explores the potential of Tinkering in educational practice through the use of bricks, highlighting how they can become an engine for meaningful learning and knowledge building through doing.

Il Tinkering è un approccio pedagogico che promuove l'apprendimento attraverso l'esplorazione, la sperimentazione e la creatività. Basato sul concetto di Pensiero Creativo, consente agli studenti di sviluppare il pensiero critico e creativo risolvendo i problemi in modo intuitivo e iterativo. Un esempio emblematico di questa metodologia è l'uso dei mattoncini LEGO®, strumenti versatili che consentono agli studenti di costruire, smontare e rielaborare idee in un continuo processo di scoperta e innovazione. I mattoncini LEGO®, inseriti in un contesto educativo, favoriscono lo sviluppo delle competenze STEAM e incoraggiano la collaborazione, la resilienza e la risoluzione dei problemi. Il presente studio esplora il potenziale del Tinkering nella pratica educativa attraverso l'uso dei mattoncini, evidenziando come questi possano diventare un motore per un apprendimento significativo e la costruzione di conoscenza attraverso la pratica.

KEYWORDS
Tinkering; Embodied learning; Spatial cognition; Creative thinking; Pedagogy.
Tinkering; Apprendimento incarnato; Cognizione spaziale; Pensiero creative; Pedagogia.

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Introduction

In the contemporary educational landscape, marked by rapid social, cultural and technological transformations, the need to rethink teaching-learning processes in an interdisciplinary and student-centered perspective emerges forcefully. The challenges posed by the complexity of today's world require teaching approaches capable of promoting transversal skills, critical thinking and creativity, while at the same time enhancing the experiential dimension of knowledge. In this context, active and laboratory methodologies are configured as privileged tools to stimulate autonomy, engagement and meaningful learning. Among these methodologies, Tinkering has established itself in recent years as an innovative pedagogical practice, capable of integrating creative doing with critical reflection, within flexible and stimulating environments. Founded on solid theoretical foundations, ranging from Piagetian constructivism (Piaget, 1972) to Papert's constructionism (1991), up to the most recent contributions on embodied cognition (Varela, Thompson & Rosch, 1991), Tinkering promotes an idea of knowledge as an active and situated construction, in which the body and interaction with the environment play a central role.

In particular, the use of LEGO® bricks represents a concrete and effective application of this educational philosophy: physical manipulation, the possibility of building and rebuilding, the modularity of the elements offer students the opportunity to explore complex concepts in an intuitive, creative and collaborative way. The Tinkering approach, especially in STEAM contexts (Science, Technology, Engineering, Arts, Mathematics), therefore allows us to overcome traditional disciplinary fragmentation and to promote the integration between theoretical and practical knowledge.

The aim of this paper is to investigate the pedagogical potential of Tinkering and the didactic use of LE-GO® in the promotion of STEAM skills, highlighting the theoretical assumptions, the methodological implications and the educational implications of this approach. Through a reflection based on a post-constructivist perspective, it is intended to show how Tinkering can represent a valid tool for the design of inclusive, dynamic learning environments capable of enhancing the multiplicity of cognitive styles and intelligences.

1. Tinkering and educational culture: contexts, origins and international developments

To fully understand the pedagogical scope of Tinkering, it is appropriate to analyze its historical and cultural roots, conceptual references and operational declinations that have marked its evolution, especially in relation to formal and informal educational contexts. Tinkering was born at the intersection of scientific education, maker culture and pedagogies of doing, taking shape starting from the 2000s within educational research centers and American science museums, such as the Exploratorium in San Francisco, which played a pioneering role in its diffusion (Bevan, Gutwill, Petrich & Wilkinson, 2015).

The term "tinkering" has Anglo-Saxon origins and recalls the idea of fixing, experimenting, trying and trying again with the hands, without a predefined plan, but with a strong exploratory intentionality. In the Anglophone tradition, the tinkerer is a curious artisan figure, who learns through doing, through direct contact with objects and the material world. Transferred to the educational field, this concept is enriched with epistemological and formative value, transforming into a methodology that combines play, design, manipulation and reflection. Tinkering, therefore, is not just a laboratory practice, but a real "educational culture" that promotes the centrality of experience, the value of error, the importance of documentation and the collaborative construction of knowledge. In the international context, Tinkering has met with great attention within the movements for the diffusion of STEM/STEAM education, finding application not only in school contexts but also in FabLabs, creative ateliers, museums and non-formal learning centers. The approach has been promoted and systematized by authors such as Resnick (2017), who, in the context of the activities of the Lifelong Kindergarten Group at the MIT Media Lab, highlighted the value of "learning through making" and the shared construction of knowledge through material and digital artifacts. Tinkering is also integrated with the philosophy of the Maker Movement (Martinez & Stager, 2013), which has played a decisive role in bringing design culture, 3D printing, educational robotics and programming to schools.

In Italy, Tinkering has gradually spread in contexts of educational innovation and laboratory experimentation, finding resonance in initiatives promoted by scientific museums, school networks, third sector entities and private foundations. Some projects, such as those supported by the Reggio Children Foundation or by museums such as the MUSE in Trento, have interpreted Tinkering in a pedagogical way, intertwining it with theories of situated learning, social constructivism and documentation as a tool for reflection. The dialogue between formal and informal

education, between academic knowledge and community practices, has helped to outline a vision of Tinkering as a flexible, adaptable practice, attentive to the relational dimension and oriented towards co-construction.
In its development, Tinkering has therefore taken on multiple configurations, but all of which can be traced back to some common traits: the centrality of the process with respect to the product, the value attributed to error as an integral part of learning, the combination of analog and digital materials, the promotion of personal initiative and collaboration. These elements make it a pedagogical approach consistent with the purposes of inclusive schooling and the integral formation of the person. Furthermore, its inter- and transdisciplinary nature allows to address in an integrated way issues related to sustainability, civic education, creativity and innovation, in a perspective of an open and flexible curriculum.
In conclusion, understanding Tinkering in its cultural and systemic dimension allows to grasp not only its methodological value, but also its transformative scope towards the identity of the school and the role of the teacher. Inserting tinkerable practices in educational contexts means embracing a vision of learning as a meaningful exploration, as a dialogue between hands, mind and environment, as a collective process of research and construction of meaning.

2. Theoretical foundations of Tinkering: constructivism, constructionism and embodied cognition

Tinkering is configured as a complex and multidimensional pedagogical approach, which draws its roots from different convergent theoretical frameworks: Piagetian constructivism, Papertian constructionism and the theory of embodied cognition. The integration of these models allows us to interpret learning not as a linear process of transmission of knowledge, but as a creative, situated and bodily rooted activity, in which the student actively constructs meanings through doing.

2.1 Constructivism: learning through action

According to constructivism, knowledge is not simply received from the outside, but built internally by the subject in interaction with the environment. Jean Piaget (1972) argues that cognitive development occurs through a continuous reorganization of mental structures, thanks to the interaction between assimilation and accommodation processes. In the educational field, this implies the need to offer students concrete, manipulative and significant experiences that encourage the autonomous construction of knowledge.

In Tinkering, this vision translates into the centrality of direct experience: through experimentation with physical materials — for example LEGO® bricks, electronic circuits or recycled objects — the student explores, tests, modifies and gives meaning to his own constructions, developing cognitive and metacognitive skills at the same time.

2.2 Constructionism: thinking with your hands

Constructionism, developed by Seymour Papert (1980, 1993), a student and collaborator of Piaget, represents an evolution of constructivism in a technological and design key. Papert emphasizes the importance of the construction of shareable artefacts as a vehicle for deep learning: learning is not only "building in the mind", but also building something tangible in the world. This process has a double value: it allows to externalize thought in a concrete form and promotes reflection on one's own work (thinking about thinking).

In the context of Tinkering, the constructionist approach manifests itself in the creation of significant objects, often made collaboratively, which stimulate a sense of belonging and intrinsic motivation. The constructed artefacts - robots, prototypes, artistic installations - become means to tell stories, solve problems and represent knowledge, transforming teaching into an expressive, creative and personalized space.

2.3 Embodied cognition: the body as a cognitive resource

As a complement to these perspectives, the theory of embodied cognition (Gomez Paloma, 2013) broadens the understanding of learning processes, highlighting the central role of the body and motor actions in the construction of knowledge. According to Varela, Thompson and Rosch (1991), cognitive activity is not confined to the individual mind, but emerges from the dynamic interaction between brain, body and environment. In this model, thinking is corporeal, situated and intersubjective.

In Tinkering, corporeality is expressed in the use of hands as cognitive tools: manipulating bricks, cutting, gluing, assembling and disassembling constitutes a way of “thinking through doing”. This type of sensorimotor learning contributes to the development of spatial, visuo-constructive and logical skills, which are especially fundamental in STEAM contexts. The environment thus becomes not only a neutral background, but an active part of the knowledge process, which shapes and is shaped by the students' actions.

2.4 Intersection of models: from theoretical knowledge to embodied knowledge

The strength of Tinkering lies in its ability to hold together these three perspectives: learning as autonomous construction (Piaget), as meaningful planning (Papert), and as embodied experience (Varela et al.). In this systemic **vision, the tinkerable** laboratory is not only an equipped space, but an open training environment, where dialogue, cooperation, creativity and divergent thinking are valued.
The tinkerable approach breaks down traditional disciplinary barriers, inviting a transversal and post-constructivist pedagogy, which considers error as an integral part of the process and promotes a learning culture centered on curiosity, exploration and co-construction of knowledge.

3. Building to think: LEGO® bricks as tools for STEAM

One of the most emblematic aspects of Tinkering is the use of LEGO® bricks as an educational medium to explore complex concepts through play, design and construction. The modular, manipulable and reusable nature of these tools makes them particularly suitable for supporting learning that is at the same time exploratory, creative and collaborative.

3.1 Divergent creativity and problem solving

The use of LEGO® fits fully into a perspective of divergent creativity, a concept theorized by J. P. Guilford (1950), who defines it as the ability to produce multiple original solutions to a given problem. The bricks, due to their flexibility, offer an ideal context to develop this ability: students are not asked to find a single answer, but to explore, test and prototype different design possibilities.
This type of activity falls within the logic of design thinking, which values iteration, empathy and error as fundamental stages in the innovation process (Brown, 2009). LEGO® thus becomes a cognitive and expressive tool, capable of supporting design thinking and promoting experiential learning.

3.2 Collaborative work and social skills

Another distinctive aspect of the use of LEGO® in Tinkering concerns the collaborative dimension. In educational laboratories, students often work in groups to create common constructions, developing communication skills, negotiation

skills and active listening. This promotes the construction of transversal skills that are increasingly in demand in the world of education and work: critical thinking, shared leadership, ability to solve problems creatively.
The shared construction of artefacts also promotes a sense of belonging to the group, stimulates dialogue and reduces barriers related to cultural or linguistic differences, making the tinkerable approach a potentially inclusive and democratic practice.

3.3 Tinkerable environments: materials, context and agency

The concept of tinkerability, developed by Resnick and Rosenbaum (2013), defines the quality of an educational environment that promotes autonomous exploration, error and experimentation. A tinkerable environment does not limit itself to offering advanced technological tools, but is configured as an open pedagogical space, where students can follow their own interests, try and modify their own projects, learn through comparison and self-reflection.
In this type of environment, LEGO® represents a privileged material to support the personalization of the path: each student can build differently, according to their cognitive style, and find unique ways to represent concepts, ideas or emotions.
This approach favors the development of self-determination (Deci & Ryan, 1985) and agency (Bandura, 2001): students feel like active authors of their own learning, capable of influencing the process and the results. This helps fuel a deep intrinsic motivation, which is based on the pleasure of creating, exploring and understanding.

4. Agency, self-determination and inclusion in tinkerable paths

The pedagogical approach of Tinkering stands out not only for its laboratory and creative dimension, but also for its profound ability to activate educational processes centered on the student, enhancing their autonomy, uniqueness and transformative potential. Within tinkerable environments, the student is not a passive receiver of content, but an active builder of knowledge, able to explore, experiment and reflect personally on their learning. This educational protagonism is closely connected to the concept of agency, understood as the ability of the individual to act intentionally, exercising influence on their environment and on the direction of their educational path. According to Albert Bandura (2001), agency represents one of the fundamental components of human subjectivity, because it

allows individuals to attribute meaning and purpose to their actions, developing a feeling of self-efficacy that strengthens motivation and self-esteem. In educational contexts inspired by Tinkering, agency manifests itself when students are free to make choices, to follow their own interests, to take responsibility for their own project: deciding what to build, how to proceed, when to modify or rework an idea represents an act of profound self-determination that transforms learning into a lived and meaningful experience. The self-determination theory developed by Deci and Ryan (1985) helps us understand how and why tinkerable educational contexts are able to stimulate intrinsic motivation. According to this theoretical model, human beings are naturally oriented towards learning when three fundamental psychological needs are satisfied: competence, autonomy and relationality. Tinkering responds to these needs in an organic way: construction activities offer concrete and progressively more complex challenges, capable of nurturing the sense of competence; freedom of choice and the exploratory approach strengthen autonomy; cooperative work, which often characterizes tinkerable projects, supports the construction of meaningful relationships with peers and with the adult mediator. Furthermore, the fact that the error is welcomed as an integral part of the process – and not as a failure – contributes to creating an emotionally safe climate, within which students can express themselves without fear of judgment.
A further strength of Tinkering lies in its intrinsic ability to promote inclusion and personalization of paths. The proposed activities are in fact open, flexible, non-linear: each student can proceed at their own pace, choose materials and strategies, rework the task according to their own cognitive and expressive sensitivity. In this sense, the tinkerable approach proves particularly suited to responding to the complexity of contemporary classes, characterized by growing cultural, linguistic and neurodivergent heterogeneity. The adoption of laboratory and operational methodologies, based on action and manipulation, allows supporting the learning of even those students who, within more traditional teaching settings, experience difficulties related to verbal coding, abstraction or the rigid temporality of content. Through the use of LEGO® bricks, for example, it is possible to translate complex concepts into tangible forms, build visual metaphors, explore logical and symbolic connections in a corporeal and intuitive way, thus promoting cognitive accessibility and active involvement.
In this context, it becomes clear how Tinkering can support an inclusive and post-constructivist pedagogical vision, in which the body, the environment, emotions and relationships are considered constitutive elements of the learning process. Doing with your hands, shared planning, documentation of the paths and metacognitive reflection represent teaching devices through which not only

disciplinary knowledge is built, but also a sense of self, belonging and responsibility. The tinkerable laboratory is then configured as a generative educational space, in which knowledge emerges from the interaction between subjects, materials and context, in a systemic and interconnected perspective. Promoting agency and self-determination through Tinkering means, ultimately, restoring centrality to the student as a person in learning, capable of giving shape, value and meaning to his or her own path.

5. Beyond fragmentation: Tinkering between post-constructivism, experientiality and educational transversality

In recent decades, pedagogy has progressively shifted its center of gravity from a transmissive and disciplinary model to more open, dialogic and dynamic paradigms, capable of accommodating the complexity of the educational experience. In this scenario, the Tinkering approach is configured as a concrete proposal to rethink teaching in a post-constructivist way, overcoming the limits of a vision of learning anchored exclusively to the individual cognitive dimension, and opening up to a broader, more corporeal, relational and situated understanding of knowledge.
Post-constructivism, as it is emerging in the pedagogical and didactic field, does not abandon the fundamental acquisitions of Piagetian constructivism or Papertian constructionism, but integrates them with new epistemological and methodological sensibilities. Among these, we highlight the recognition of the complexity of educational contexts (Sibilio, 2012), the attention to emotions, the body and the environment, the interest in the social and cooperative processes of learning. Tinkering fully responds to this need for expansion and integration, offering students authentic learning opportunities that enhance concrete experience, divergent thinking, shared planning and reflexivity. A distinctive element of the tinkerable approach is its epistemological and disciplinary transversality (Gaspari, Lombardi & Testa,, 2023). In Tinkering laboratories, the boundary between disciplines tends to dissolve, leaving room for experiences in which scientific, technical, artistic, linguistic and relational skills are intertwined. In this sense, Tinkering presents itself as an effective methodological response to the STEAM (Science, Technology, Engineering, Arts and Mathematics) approach, which aims to promote integrated training oriented towards creative problem solving. Building a model with LEGO®, creating an electrical circuit, designing an architectural structure or an interactive installation means simultaneously

activating different intelligences (Gardner, 1993), stimulating systemic thinking and promoting the understanding of complex concepts through doing.
This integration is not only disciplinary, but also formal and informal. Tinkering lends itself to being adopted in canonical school contexts, but also in alternative educational spaces such as museums, libraries, cultural centers, FabLabs, creative ateliers. This fluidity between educational environments allows us to recognize and enhance knowledge that often remains on the margins of the traditional school curriculum: corporeal, tacit, implicit, aesthetic knowledge. From a democratic perspective of education, Tinkering represents a pedagogical practice capable of including and connecting, promoting learning that is not limited to the repetition of content, but is built on relationships, discovery and personal transformation.
A crucial aspect in the post-constructivist perspective is the role of documentation and metacognitive reflection. In order for the educational experience not to be reduced to a simple "doing", it is necessary that it be reread, narrated, shared, integrated into a framework of meaning. In tinkerable paths, documentation - photographic, written, oral or digital - becomes an essential tool to promote awareness of learning, stimulate critical reflection and support an authentic and formative evaluation. Documenting means making the process visible, not just the product; it means restoring dignity to error, to effort, to the evolution of ideas, highlighting the transformative dimension of learning. In this framework, evaluation takes on a profoundly different meaning from the traditional one. No longer focused on performance, on formal correctness or on standardized comparison, it becomes a tool for growth and self-regulation, an opportunity to reread one's own paths and guide future choices. The evaluation criteria in tinkerable paths are based on parameters such as commitment, creativity, the ability to cooperate, persistence in the face of difficulties, the quality of the design process. The student is invited to actively participate in the evaluation process, through forms of self-assessment, co-assessment and peer assessment, with a view to educational co-responsibility. The tinkerable laboratory, understood as a pedagogical ecosystem (Ellerani & Patera, 2021), thus takes on a transformative function also for the teacher, who from a transmitter of contents becomes a facilitator, mediator, director of learning. The role of the teacher consists in designing stimulating contexts, asking generative questions, offering support tools, documenting the paths, promoting reflection. A teaching centered on transversality and complexity requires a profound rethinking of professional practices and pedagogical epistemologies: no longer teaching a discipline, but designing experiences that generate significant and transformative learning. Finally, Tinkering can also be read as an opportunity to address, at an educational level, the great

contemporary challenges: sustainability, active citizenship, digital education, inclusion. Building together, experimenting with solutions, tackling real problems through design and creativity allows students to develop global citizenship skills (Donato, 2023), critical thinking and social responsibility. In this sense, Tinkering is not just a teaching methodology, but a broad and profound educational vision, capable of combining knowledge and doing, theory and practice, individual and community.

6. Time and space in Tinkering: environments that educate, times that liberate

One of the most frequently underestimated aspects in educational planning concerns the configuration and management of learning time and space. In many school contexts, these two dimensions are still treated as secondary or neutral elements, to be planned according to organizational needs rather than as pedagogical devices in themselves. The Tinkering approach, on the other hand, foregrounds the role of space and time, recognizing their transformative scope and autonomous educational function. In this perspective, the environment is not a passive container, but a true "third educator" (Malaguzzi, 1996), capable of stimulating, welcoming, organizing and enhancing the students' educational experience.

6.1 The environment as a generative space for learning

Tinkering promotes an idea of educational space that is profoundly different from the traditional one. While frontal teaching tends to favor orderly, symmetrical and static environments - such as the classroom with aligned desks and a central teacher's desk - tinkerable contexts are dynamic, modular and relational. The furnishings are mobile, the materials accessible and arranged in a way that encourages autonomous exploration, experimentation and interaction. Work tables, open shelves, thematic corners, soft areas, digital tools, recycled objects: everything contributes to the creation of a multimodal environment (Amico, 2012), capable of activating different forms of intelligence (Gardner, 1993) and of enhancing individual and collective expressiveness. The construction of the tinkerable space occurs in a participatory way: students do not limit themselves to inhabiting the environment, but contribute to designing it, modifying it and adapting it based on the needs of the group and the nature of the projects in progress. In this sense, the environment becomes an extension of thought and an ally of the creative process. Building a tinkerable space means creating a context in which objects speak, suggest actions, and evoke possibilities. Every corner can be transformed into an educational opportunity: a drawer of materials becomes a mine of ideas; a free table turns into a design laboratory; a bare wall hosts the documentation of the paths. The tinkerable space is also an inclusive space, capable of welcoming and valorizing diversity. Thanks to the plurality of materials, tools, and languages that can be used, each student can find an expressive modality suited to their cognitive, emotional, and sensorial characteristics. Furthermore, the organization of the space encourages collaboration and interaction between peers, breaking down traditional hierarchies and promoting forms of cooperative and dialogic learning (Vygotskij, 1934,1978).

6.2 The qualitative time of experiential learning

Alongside space, time is also a fundamental variable in Tinkering. Contemporary school, in its most widespread configuration, is still bound to a chronological and segmented logic, which divides teaching activity into predefined hours, rigidly structured and often disconnected from the nature of cognitive processes. Tinkering, on the contrary, proposes a kairological approach (D'Aprile, 2018) to educational time: not the time of the clock, but the appropriate time, the time of the event, of intuition, of prolonged concentration and of reflective review.

Tinkerable paths require extended, non-linear times, capable of accommodating uncertainty and rethinking. The creative and planning process, by its nature, cannot be compressed into fixed temporal units: it requires exploration, trials, errors, abandonments and returns. The iterative logic of experiential learning (Kolb, 1984) is based on cycles of action and reflection, which are difficult to reconcile with the typical fragmentation of school time. In this sense, promoting Tinkering also implies radically rethinking the organization of teaching time (Palma & Galimberti, 2024), restoring centrality to depth, immersion and slowness.

The time of Tinkering is also an emotional time, crossed by curiosity, frustration, enthusiasm, surprise. It is a subjective and collective time at the same time, in which learning occurs as a lived and shared experience. This time must be recognized, respected and protected: it is necessary to create the conditions so that students can truly dwell in the experience, inhabit it, transform it into conscious knowledge. In this sense, Tinkering is configured as a form of pedagogical resistance to the school of efficiency and performance, and as an ethical as well as methodological proposal.

6.3 Environments and times for a transformative school

Rethinking space and time ultimately means rethinking the school in its entirety. Tinkering, by proposing flexible environments and authentic times, opens the way to a transformative school, capable of embracing the complexity of reality and the plurality of cognitive, emotional and relational styles. A school that does not only measure correctness, but the path; that does not only reward the result, but the process; that does not only propose content, but opportunities for meaning.

In this vision, the educational space becomes a metaphor and instrument of the pedagogical relationship: a space that welcomes, that stimulates, that accompanies. And time becomes an ally of learning, rather than a constraint: time to make mistakes, to change your mind, to imagine and create. Time to think with your hands, to design together, to go back and start again. Time to educate for freedom, responsibility, the co-construction of knowledge.

Tinkering ultimately invites us to move beyond the idea that the "where" and "when" of learning are secondary data. Instead, it teaches us that every learning process needs a space that makes it possible, and a time that makes it meaningful. Taking up this challenge means imagining a school capable of generating places and moments in which learning can be not only effective, but authentically human.

Conclusions: Tinkering as a pedagogical challenge for the school of the future

In light of the reflections conducted, Tinkering is configured not only as an innovative teaching methodology, but as a real epistemological and pedagogical challenge (Gaspari, 2024) aimed at contemporary school. In a time marked by rapid cultural, technological and social transformations, education is called to deeply rethink its paradigms, to restore meaning, motivation and inclusiveness to learning processes. Tinkering, with its attention to doing, planning, creativity and the experiential dimension, offers a concrete alternative to the transmissive and standardized models that still characterize much of school practice.

The entire theoretical framework that supports Tinkering – from constructivism to constructionism, from embodied cognition to design thinking – converges towards a vision of learning as an active, situated, dialogic and multisensory process (Morsanuto, Ludovisi & Cassese, 2022), in which the student builds knowledge not only through the passive reception of contents, but through bodily, symbolic and social interaction with the environment and with others. Educational materials, such as LEGO® bricks, represent powerful cognitive tools, capable of transforming abstract ideas into concrete artefacts, making thought visible and even the most complex contents accessible. The transformative potential of Tinkering also lies in its ability to promote agency, self-determination (Aiello, Di Gennaro, Sibilio & Zollo, (2017) and intrinsic motivation. In a time when schools often struggle to engage students in an authentic way, this methodology allows to reactivate the desire to learn, offering spaces for choice, creativity, experimentation and collaboration. Tinkerable paths recognize the centrality of the student as a competent and responsible subject, capable of deciding, planning, making mistakes and improving, within educational contexts that value autonomy and respect personal rhythms.

At the same time, Tinkering proves to be particularly suitable for promoting school inclusion, thanks to the flexibility of its proposals, the plurality of languages it uses (visual, corporeal, spatial, material) and the possibility of personalising access to knowledge according to different cognitive styles. In this sense, it is in line with the most recent demands of inclusive education, which rejects homologation and recognises the value of differences as resources for learning. In contexts tinkerabili, each student can find their own space for expression and participation, developing disciplinary, but also relational, ethical and aesthetic skills.

A further important element is represented by the possibility of rethinking the role of the teacher: in Tinkering, the teacher is no longer a simple transmitter of content, but becomes a facilitator and director of learning (Fiorucci, 2019), capable of designing meaningful environments, asking authentic questions, observing and documenting, guiding reflective processes. This change in perspective requires a profound transformation of the teaching profession, based on advanced pedagogical, relational and design skills, but also on the willingness to welcome uncertainty, experimentation, and error as generative moments of the educational process. Furthermore, Tinkering allows the school to organically approach STEAM disciplines, helping to overcome the fragmentation of knowledge into watertight compartments and to promote a culture of complexity. Interdisciplinary design activities allow mathematical logic to be combined with artistic creativity, engineering thinking with personal expression, technology with critical reflection. In this way, the student is put in a position to face real problems, develop innovative solutions and develop systemic thinking, which is essential to inhabit the contemporary world in a conscious and responsible way.

Particular attention, as discussed in the previous section, deserves the documentation of the processes and authentic evaluation. In order for Tinkering not to be reduced to an impromptu laboratory activity, it is necessary that the

experiences are enhanced through metacognitive reflection, the narration of the paths, the recognition of the goals achieved. In fact, the documentation not only allows students to acquire awareness of their own strategies and progress, but also becomes a tool for dialogue between teacher, student and family, strengthening the educational alliance. Similarly, the evaluation must take into account the complexity of the process, the value of intuitions, the ability to learn from mistakes and to collaborate effectively. In this sense, Tinkering requires a profound rethinking of evaluation practices, aimed at enhancing what often escapes traditional grids: creative thinking, resilience, planning ability.
In light of the above, it is clear that Tinkering can represent a driving force for educational innovation, capable of combining disciplinary content and transversal processes, scientific and humanistic culture, formal and informal knowledge. It invites us to rethink teaching as a transformative experience, as a place for constructing meanings, as a space for shared and non-prescriptive research. However, its introduction into school contexts cannot be reduced to a methodological trend or a simple instrumental update. On the contrary, it requires a profound cultural change, involving the vision of the school, the curriculum, the organization of spaces, teaching time, teacher training, dialogue with the territory.
In conclusion, Tinkering represents a powerful opportunity to renew education towards a pedagogy of participation, corporeality and complexity (Barra, 2021), capable of training creative, autonomous and responsible citizens. In a rapidly changing world, where challenges are global, interconnected and unpredictable, educating in design thinking, in error as a resource, in collaboration and in the shared construction of knowledge appears not only desirable, but necessary. The school of the future, to be authentically inclusive and transformative, will have to be able to welcome this challenge with courage, imagination and competence.

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