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PHYSICAL EDUCATION AND CREATIVITY IN STEAM CONTEXTS

An transdisciplinary intervention for aesthetic and visual production in primary education

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ABSTRACT

This study analyzes the effect of the transdisciplinary program "Visual and Embodied City" on the creativity of 85 elementary school students. Using a quasi-experimental design, Physical Education, Social Sciences, and Language Arts were combined to work on embodied cognition and digital culture. The results show significant improvements in total creativity scores, especially in originality (d = 0.90), fluency, and flexibility. Intrinsic motivation correlated strongly with performance (r = .70). It is concluded that Physical Education is a key mediator for innovation and understanding abstract concepts in STEAM contexts.

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1. Introduction

In the current juncture of the knowledge society, defined by unprecedented technological acceleration, the ubiquity of digitalization, and the emergence of global systemic challenges, contemporary educational systems are forced to confront a critical crossroads: the imperative need to transcend the linear and fragmented instructional models inherited from the industrial era, moving toward more complex models of media apprehension (Soto Ocampo, 2023). Reference international organizations such as UNESCO (2021) and the OECD (2019) have postulated a new social contract for education, identifying creativity, collaboration, and critical thinking not as peripheral skills or mere artistic attributes, but as fundamental ontological competencies for navigating environments characterized by uncertainty, ambiguity, and structural complexity. In this scenario, education must evolve toward a paradigm that prioritizes the students' ability to transform theoretical knowledge into innovative, ethical, and sustainable action, moving beyond passive memorization in favor of the active construction of knowledge.

Despite the global theoretical consensus on the relevance of these competencies, empirical reality in Primary Education classrooms reveals a persistent structural gap between curricular aspirations and effective teaching praxis. The compartmentalization of knowledge into isolated disciplinary "silos" continues to represent one of the greatest epistemological obstacles to deep and meaningful learning. Recent scientific literature suggests that this fragmentation drastically limits students' ability to perform effective cognitive transfers between domains and to propose original solutions to real-world problems that are, by their very nature, intrinsically interdisciplinary. According to authors such as Danielson et al. (2022), the dominant curricular structure, often perceived as a sequence of discrete and delimited time slots, significantly reduces the potential of integrative approaches, frequently relegating the arts and humanities to a purely subsidiary or decorative role compared to traditional technical and scientific outcomes.

As a response to this fracture of knowledge, the STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach has emerged over the last decade as a disruptive paradigm capable of mitigating curricular fragmentation and promoting a holistic synthesis of learning. Although the original STEM model was born with a markedly economic orientation focused on technological competitiveness, the inclusion of the "Arts" has represented a qualitative transformation of the educational framework toward a more human, creative, and culturally situated vision (Gradín and Ezquieta, 2022). However, the true power of the STEAM approach lies not in the mere juxtaposition of subjects, but in its ability to invoke the centrality of the image as a vehicle for systemic thinking and a design tool (Makhlouf and Iñigo, 2022). The image, understood not only as a figurative representation but as a mental schema and problem-solving device, acts as the necessary semantic bridge to connect scientific abstraction with physical and social tangible reality.

Nevertheless, a critical analysis of current scientific production on the implementation of this approach in primary education reveals a marked technical bias, with a predominant focus on the integration of robotics, programming, and computational thinking. This approach has left a notable empirical void regarding how disciplines traditionally considered "non-technical", specifically Physical Education and Social Sciences, can act as cornerstones of creative thinking and academic innovation. This omission is particularly critical in the case of Physical Education and its intrinsic relationship with embodied or grounded cognition. This neurocognitive perspective maintains that the processes of thought, reasoning, and learning do not occur in an abstract or purely cerebral vacuum, but are deeply rooted in physical interaction with the environment and bodily movement.

Under this prism, Physical Education ceases to be a subject of mere motor release to become an epistemological laboratory where the body acts as the primary medium for representing reality. Contemporary research emphasizes that movement and spatial awareness not only improve physical health but also facilitate the internalization of abstract and complex concepts, enhancing cognitive flexibility and originality through sensory experimentation (Almarcha et al., 2022). In terms of cognitive architecture, the use of the body allows for what is called "cognitive

offloading," a mechanism through which the motor representation of systems and the physical manipulation of elements relieve the load on working memory, freeing up cognitive resources for higher-order creative thinking processes (Castro-Alonso et al., 2024).

This work is based on the synergy between movement and visuality. By asking students to translate dynamic urban processes, such as energy flows or community connectivity, into original choreographic sequences and design prototypes, a multimodal understanding is activated that purely verbal instruction is unable to achieve. This approach breaks with the Cartesian mind-body dualism that has historically dominated the school curriculum, positioning motor skills as an engine for abstraction and mental flexibility. Likewise, hybridization with Social Sciences and Language Arts provides the ethical context and narrative necessary for technological innovation to respond to real challenges of sustainability, equity, and social well-being. For students to develop genuine problem-solving skills, they must be able to analyze social reality and community inequalities before proposing engineering designs. In this sense, the transdisciplinary STEAM approach fosters cultural intelligence and global awareness, intrinsic components of divergent thinking.

Creativity, the central construct of this research, is operationally defined as the ability to produce ideas that are simultaneously original (novel) and appropriate (valuable and functional) within a given context (Soto et al., 2015). Following the multidimensional model of Guilford (1967) and Torrance (2008), creative thinking unfolds through four fundamental dimensions: *fluency* (quantity of ideas generated), *flexibility* (variety of conceptual categories), *originality* (statistical rarity of responses), and *elaboration* (level of detail and technical complexity of the product). Although previous literature indicates that STEAM programs can have a positive impact, there is an urgent need to investigate how the specific hybridization of diverse areas, centered on the body and the image, influences each of these dimensions differentially, especially in the face of the attention economy phenomenon and cognitive load, where the effort to achieve high originality in systemic tasks may limit the level of technical elaboration.

A determining factor that literature closely links to creative performance is intrinsic motivation and the socio-affective climate of the classroom. The Self-Determination Theory of Deci and Ryan (2000) suggests that when students perceive autonomy, competence, and social relatedness in their learning tasks, key elements of the Project-Based Learning (PBL) strategy in STEAM contexts, their cognitive engagement and willingness to take creative risks increase significantly. However, the effective implementation of these methodologies faces persistent institutional challenges, from the rigidity of school schedules to the lack of teacher training in transdisciplinary designs. Despite the surge in publications on this approach in Spain, there remains an insufficiency of empirical evidence supporting the benefits of specifically integrating Physical Education and Social Sciences through robust designs and educationally significant samples.

This study addresses this knowledge gap through advanced statistical analysis of the "Visual and Embodied City" intervention, implemented with a sample of 85 primary school students. The main objective is to determine to what extent a pedagogical proposal that hybridizes bodily movement, visual literacy, and social narrative can induce significant and sustainable changes in students' creative potential. The following working hypotheses are proposed: H1) students will show a statistically significant increase in total creative thinking scores following the intervention, with a large effect size ($d > 0.8$); H2) the dimensions of fluency and originality will experience the most pronounced growth due to the program's emphasis on open inquiry, the breaking of linear thinking, and free exploration based on embodied cognition; H3) there will be a strong positive correlation between the levels of intrinsic motivation reported by the students and their actual creative performance measured in the Post-test.

This research seeks not only to validate an innovative educational practice but to provide a solid empirical basis demonstrating that the development of creativity in childhood requires a more human, grounded, and contextualized educational approach, definitively breaking down the disciplinary barriers that limit student potential in the digital age.

2. Method

Below are the procedures, tools, and methodological criteria followed to address the objectives established in the study.

2.1. Research design

This research is structured under a quasi-experimental single-group design with repeated measures (pre-test and post-test), a methodological choice that responds to the imperative need to study educational phenomena in their natural context, preserving the systemic complexity of the classroom. Unlike pure experimental designs, which often sacrifice contextual reality in favor of variable control through artificial randomization, this approach prioritizes the "ecological validity" of the intervention (Sawyer, 2019). In the field of contemporary pedagogical innovation, especially when addressing multifaceted constructs such as creativity and embodied cognition, it is essential to observe how learning dynamics emerge in non-aseptic environments, where social interactions and school culture play an inescapable mediating role (Fullan, 2019).

Recent scientific literature emphasizes that traditional curricular fragmentation limits cognitive transfer between domains. Therefore, imposing a strict control group within the same educational center could have generated intergroup contamination or raised ethical dilemmas by depriving a portion of the students of a potentially beneficial learning experience during a prolonged 10-week period. Instead, the intra-subject design allows for the evaluation of the student's own evolution as their own control, analyzing growth trajectories in creative cognition before and after intensive exposure to the program. Although the limitations inherent to pre-experimental designs regarding internal validity are recognized, specifically the threat of natural maturation, the duration of the intervention (10 weeks) and the magnitude of the expected effects ($d > 0.8$) suggest that the observed changes could hardly be attributed to the mere passage of time. Creativity, understood as a stable cognitive trait in the absence of specific training, does not usually experience significant spontaneous fluctuations in such short periods without a disruptive pedagogical stimulus.

2.2. Participants

The study was conducted with a purposive and representative sample of 85 fifth-grade primary education students (Table 1). The selection of this educational level was not arbitrary; students between 10 and 11 years of age are at a critical stage of cognitive development in transition toward formal operational thought, where the capacity for abstraction begins to consolidate, but where, paradoxically, a decline in graphic and motor creativity is also observed due to pressure from school and social standardization (Torrance, 2008). The mean age of the participants was 10 years (SD = 0.52), ensuring suitable developmental homogeneity for the administration of the selected psychometric tests. Regarding gender distribution, the sample presented an appropriate balance, with 44 boys (51.7%) and 41 girls (48.3%), allowing for subsequent analyses free from significant gender bias in the interpretation of motor creative performance.

Table 1. Breakdown of the sample and context

Variable	Category	n	%
Gender	Male	44	51.7%
	Female	41	48.3%
Age	10 years	49	57.6%
	11 years	36	42.4%
Level	5th Grade Primary Education	85	100%
Context	Urban / Middle socioeconomic status	-	-

Note. n = number of participants in the subcategory; % = percentage calculated based on the total sample. The context category describes the sociodemographic environment of the educational center in Seville where the intervention was conducted.

The intervention context was a subsidized private educational center located in a middle-class urban area in the province of Seville, Spain. The choice of an urban setting was strategic for the project's theme, as the students' immediate environment served as a living laboratory for inquiry. The participants shared a similar cultural background, with moderate prior exposure to active methodologies, but zero experience in transdisciplinary integration programs that explicitly linked Physical Education with visual semiotics and urban design.

The ethical integrity of the research was safeguarded through a rigorous protocol aligned with the principles of the Declaration of Helsinki (World Medical Association, 2013). Prior to the start of the diagnostic phase, families were invited to an information session where the study's objectives (fostering creativity through the body and image), the nature of the activities (with no physical risk greater than that of an ordinary Physical Education class), and the data handling procedures were detailed. Written informed consent was obtained from the legal guardians of all minors. Verbal assent was requested from the participants for their involvement in the assessment tests and the recordings of the practical sessions. The processing of psychometric data and field observations was carried out under a strict pseudonymization protocol, assigning random numerical codes to each participant to dissociate their identity from their results, in compliance with the European Union's General Data Protection Regulation (GDPR) (Regulation (EU) 2016/679, 2016), ensuring that the intervention respected the dignity and emotional well-being of the students.

2.3. Procedure

The program was designed as an operational response to the crisis of curricular fragmentation that characterizes conventional primary education. While traditional STEAM approaches typically pivot around robotics or programming as integrating axes, this proposal reorients the focus toward humanistic and bodily disciplines, which are often marginalized or instrumentalized. The intervention's architecture positions Physical Education as the backbone of learning, drawing on the theories of embodied cognition. This perspective asserts that higher cognitive processes, such as creativity, urban planning, or symbolic analysis, are not abstract brain computations but are deeply rooted in the body's sensorimotor interaction with the environment. Thus, movement is not used here as an active break or recess, but as a thinking mechanism: "thinking with the body" to solve spatial and social design problems. Complementarily, the concept of "Visual Culture" acts as connective tissue. In a society saturated with images, critical visual literacy is an ontological competency. The program challenges students not to be mere consumers of urban aesthetics, but active producers of new visual and spatial imaginaries, thereby integrating Social Sciences (analysis of reality) and Language (narrative and persuasion) into a coherent whole.

The intervention took place over a 10-week period, which allowed for deep immersion and the consolidation of divergent thinking habits. The teaching load was approximately 6 hours per week, distributed among the three involved curricular areas, but with their boundaries reduced through shared projects. The pedagogical itinerary was organized into four evolutionary phases that guided the students from the deconstruction of their immediate reality to the creative proposal of a new urban scenario (Table 2).

Table 2. Phases of the intervention

Phase	Cognitive Focus	Key Activity in Physical Education	STEAM Integration (Language/Social Studies)
1. Diagnosis	Critical perception	Exploration of non-conventional spaces, breaking of motor patterns.	Mapping of urban emotions, semiotic analysis of street advertising.
2. Translation	Multimodal abstraction	Architectural acrosport: replicating visual structures with the body.	Creation of urban neologisms, study of geometric shapes in the city.
3. Design	Problem solving	Motor skills circuits simulating urban flows (energy, transport).	Layout/Modeling with recycled materials, drafting ethical regulations for the city.
4. Communication	Expressive synthesis	Narrative choreography: telling the story of the city through movement.	Persuasive oral defense, debate on sustainability and civic ethics.

The following section details the procedure followed in each of the phases.

Phase 1: sensory deconstruction and urban drift (weeks 1-2)

The initial objective was to break perceptual automatisms. In Social Sciences, students engaged in psychogeographic *dérives* (drifts) around the school's surroundings, inspired by contextual practices but adapted to the students' educational stage. It was not about going from point A to point B, but rather mapping sensations: "where do you feel fear?", "where is there visual noise?", "which spaces invite play and which cause inhibition?". In Physical Education, the focus was on the "awareness of lived space." Body exploration tasks were carried out where students had to occupy the gymnasium in unconventional ways (occupying corners,

asymmetrical formations, etc.), breaking away from the linearity of rows and columns typical of the school setting. This laid the groundwork for cognitive flexibility.

Phase 2: visual-body translation (weeks 3-5)

En In this phase, the core of the methodological innovation was established. "Intersemiotic translation" workshops were implemented, where students were required to take abstract concepts from urban visual culture (e.g., "congestion," "flow," "network," "architectural barrier") and translate them into bodily metaphors.

- Sample activity: "The Architectural Body." Groups of students observed photographs of avant-garde urban structures and had to replicate the tensions, balances, and voids using their own bodies in acrosport formations.

- Cognitive mechanism: The student must analyze the image (visual input), abstract its geometric and functional principles, and recode them into muscular tension and spatial positioning (motor output), which forces a profound mental restructuring. According to authors such as Castro-Alonso et al. (2024), this process of multimodal transcoding is a powerful stimulator of cognitive plasticity and originality.

Phase 3: urban design and prototyping (weeks 6-8)

Creativity work was oriented toward problem-solving through the PBL (Project-Based Learning) teaching strategy. Cooperatively formed teams had to design their "City of the Future" to solve a problem identified in Phase 1 (e.g., lack of green areas, excessive traffic).

a. Language: drafting the "City Constitution" and persuasive scripts to explain its functioning. Use of metaphors and neologisms to describe imaginary technologies.

b. Social Sciences: creation of plans and models using recycled materials ("trash" repurposed as a constructive resource). The aesthetics of the model (*elaboration*) were valued as much as its functionality.

c. Physical Education: design of "movement routes." How do inhabitants move in this new city? Students created motor skill circuits that simulated sustainable transport or the energy systems of their models.

Phase 4: performance and transmedia communication (weeks 9-10)

The intervention culminated in a public exhibition. Far from a static PowerPoint presentation, the students performed an "urban performance." Each group defended their project by integrating a verbal explanation of the design with a motor choreography that staged life in their city. This staging required a final synthesis of learning: the word, the image (model), and the body (dance/movement) had to communicate a single, coherent message.

2.4. Instruments

To evaluate the effect of this pedagogical architecture, traditional rote-learning assessment was avoided. Internationally validated psychometric instruments were selected and adapted, interpreting them not as simple checklists, but as "probes" capable of penetrating the black box of creative cognition and the students' emotional engagement.

a. Torrance Test of Creative Thinking (2008)

El The instrument used to assess the dependent variable (creativity) was a school adaptation of the "Torrance Tests of Creative Thinking" (TTCT), specifically the figural/graphic modality. This test is the "gold standard" in the research of said variable, but its application in this study was specifically oriented toward capturing the "creative cognition" stimulated by the visual-bodily experience. The test consists of figure completion tasks (where abstract lines must be transformed into meaningful drawings) and composition tasks (using repeated shapes to create multiple objects). Four structural dimensions of divergent thinking were evaluated, aligned with the classic model of Guilford and Torrance (Guilford, 1967):

- Fluency (generative cognition): the total number of interpretable responses. In the context of the study, it reflects the student's ability to overcome inhibition and generate a flow of ideas—a skill trained through motor improvisation during weeks 3-5.

- Flexibility (adaptive cognition): the variety of semantic categories used. It analyzes whether the student is capable of "switching gears" (e.g., moving from drawing domestic objects to

drawing spatial or technological concepts), which is directly linked to the interdisciplinary nature of the program.

- Originality (innovative cognition): the uniqueness of the response compared to the reference population. This is the critical dimension for evaluating whether exposure to "visual culture" and "bodily exploration" has allowed the student to escape conventional visual stereotypes.

- Elaboration: the amount of detail added to enrich the base idea. This dimension acts as an indirect indicator of commitment and persistence in the design task.

The reliability of the instrument in this specific sample (N = 85) was verified using Cronbach's alpha coefficient, obtaining robust internal consistency values in both the Pre-test (α = .86) and the Post-test (α = .84), which validates the stability of the measure in 10-year-old children.

To understand the mechanisms underlying creative change, an adaptation of the "Motivation Scale" in physical education, validated for the Spanish context by Moreno-Murcia et al. (2011), was employed. However, in this study, the instrument was reconceptualized to measure not only sports motivation but also "aesthetic engagement." The scale, a 5-point Likert type (1 = strongly disagree, 5 = strongly agree), was broken down into three sub-factors based on the "Self-Determination Theory" by Deci and Ryan (2000):

- Intrinsic motivation toward creation: the inherent pleasure experienced when designing the city or exploring movement ("I enjoy inventing new ways to move").

- Perception of creative autonomy: the degree to which the student feels that their visual and bodily ideas are their own and not imposed by the teacher ("I feel that I can decide what my city will be like").

- Collaboration and social relationships: the perception of the quality of creative interaction with peers during the design and performance phases.

This tool is fundamental for testing the hypothesis that a classroom climate fostering autonomy and psychological safety is the necessary breeding ground for originality to emerge (Almarcha et al., 2022).

c. Performance indicators in urban design

In addition to the psychometric tests, *ad hoc* analytical rubrics based on the criteria of Soto et al. (2015) were used to evaluate the objective quality of the final products (models and performances). Three blind evaluators (external to the intervention) scored the works based on their novelty (is the urban solution unique?), functionality (does it solve the stated problem?), and transmedia coherence (does the verbal discourse match the bodily expression?).

2.5. Statistical analysis

Data analysis was designed to provide robust inference regarding the impact of the "Visual and Embodied City" program (Table 3). Processing was carried out using the SPSS statistical package, version 27.0.

Table 3. Study variables, measurement instruments, and dimensions

Variable	Measurement Instrument	Operational Dimensions	Key Reference
Creative Cognition	TTCT (Figural)	- Fluency: Quantity of ideas. - Flexibility: Variety of categories. - Originality: Statistical novelty. - Elaboration: Technical detail.	Torrance (2008)
Aesthetic Engagement	Motivation Scale (Adapted)	- Intrinsic Motivation: Enjoyment of the process. - Autonomy: Agency in design. - Relatedness: Collaborative quality.	Moreno-Murcia et al. (2011)
Artifact Quality	Ad-Hoc Rubric	- Functionality: Viability of the urban design. - Expressiveness: Richness of the bodily performance.	Soto et al. (2015)

Note. *TTCT* = Torrance Tests of Creative Thinking, figural modality. The motivation scale was adapted to assess both the sporting dimension and the aesthetic engagement in urban design.

a. Verification of assumptions and preliminary analysis

The first step consisted of cleaning the data matrix and analyzing outliers. Given the sample size (N = 85), the normality of the distributions for the dependent variables (*fluency, flexibility, originality, and elaboration*) was verified using the Shapiro-Wilk test, which is more sensitive and appropriate for samples of fewer than 100 subjects than the Kolmogorov-Smirnov test. Visual inspection of the histograms and Q-Q plots, along with skewness and kurtosis values, confirmed that, although slight deviations existed, the distribution approximated normality closely enough to justify the use of parametric statistics.

b. Inferential analysis of change (pre-post)

To evaluate the effectiveness of the intervention, the Student's *t*-test for related samples was applied. This analysis compared the means of each creative dimension before and after the program. The statistical significance level was established a priori at $p < .05$. However, aware that statistical significance can be inflated by sample size and may not necessarily reflect practical educational relevance, the effect size was calculated using Cohen's *d*. Following Hattie's (2009) guidelines for educational interventions, values were interpreted as: small effect (0.20), medium effect (0.50), and large effect (> 0.80). It was hypothesized that the dimensions most closely linked to "free exploration" (*originality* and *fluency*) would show large effect sizes, validating the power of the embodied approach.

c. Correlational analysis: the motivation-creativity link

Finalmente, para desentrañar la relación entre el *clima socio-afectivo* y el *rendimiento cognitivo*, se ejecutó un análisis de correlación bivariada de Pearson (r). Se cruzaron las puntuaciones *Post*-intervención del TTCT con las puntuaciones de la escala de *motivación intrínseca* y *autonomía*. El objetivo fue determinar si existe una asociación positiva significativa que corrobore que la implicación y la autonomía son precursores necesarios de la producción creativa de alta calidad en el contexto escolar. Con este diseño metodológico, con una especial sensibilidad hacia la ecología del aula y la experiencia corporal del estudiante, pretende no solo medir la *creatividad*, sino documentar las condiciones pedagógicas (visuales y motrices) que la hacen florecer.

3. Results

The results obtained following the implementation of the project are presented below.

3.1. Consistency and distribution properties

The reliability of the TTCT was verified for the sample of N = 85 . Internal consistency was high at both points in time (α-*Pre* = .86; α-*Post* = .89). The Shapiro-Wilk test (Table 4) confirmed that the total score follows a normal distribution (W = .99, p >.05), validating the use of parametric tests.

Table 4. Descriptive statistics and normality tests

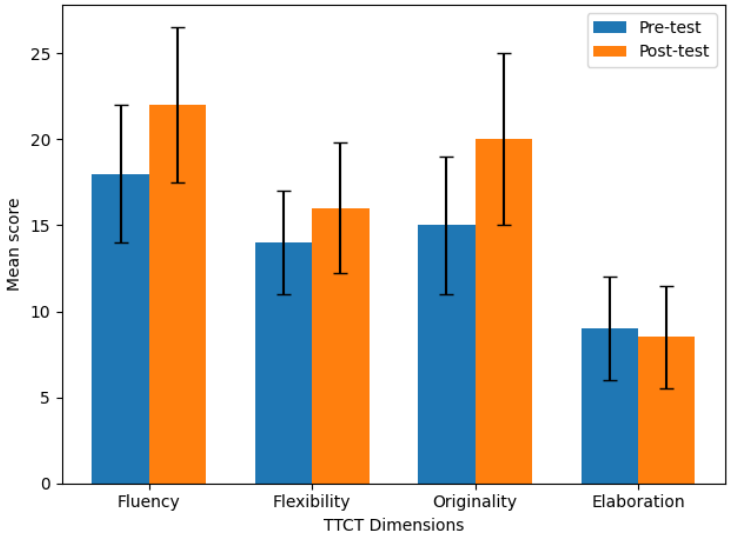
Dimension	Moment	M	SD	Skewness	Kurtosis	S-W (W)
Fluency	*Pre-test*	17.85	3.92	0.15	-0.42	.97
	Post-test	21.94	4.65	0.22	0.18	.98
Flexibility	*Pre-test*	13.92	3.15	0.40	0.12	.95
	Post-test	16.08	3.82	0.35	-0.20	.96
Originality	*Pre-test*	15.12	4.45	0.62	0.52	.93

Dimension	Moment	M	SD	Skewness	Kurtosis	S-W (W)
	Post-test	19.96	5.08	0.50	0.40	.94
Elaboration	*Pre-test*	8.85	2.75	-0.12	-0.28	.98
	Post-test	8.58	2.90	-0.15	-0.22	.97

Note. *M* = Mean; *SD* = Standard Deviation; *S-W (W)* = Shapiro-Wilk normality test statistic. The distribution is considered normal when the probability value (*p*) associated with the *S-W* test is greater than .05.

Figure 1 shows the comparison of the mean scores obtained in the TTCT dimensions at the *Pre-test* and *Post-test* stages. The bars represent the means, while the error bars correspond to the standard deviation, providing information on intra-group variability.

Figure 1. Comparison of Pre-test and Post-test measures by dimension



Note. The bars represent the mean scores obtained in each dimension of the TTCT. The vertical lines indicate the standard deviation (*SD*).

A clear increase in mean scores is observed following the intervention in the dimensions of *fluency, flexibility,* and *originality*; this increase is especially pronounced in the latter, suggesting a relevant impact of the program on the more divergent components of creative thinking. In contrast, the *elaboration* dimension shows very similar values between both moments, indicating greater stability in this component and lower sensitivity to the effect of the intervention. The magnitude of the standard deviations at both points reflects moderate variability, consistent with the heterogeneity of the creative profiles within the sample.

3.2. Impact of the intervention on the creative profile

The mean contrast using the Student's *t*-test for related samples (Table 5) revealed statistically significant increases ($p < .001$) in all dimensions except for elaboration.

Table 5. Hypothesis testing *Pre-Post* and effect size (Cohen's *d*)

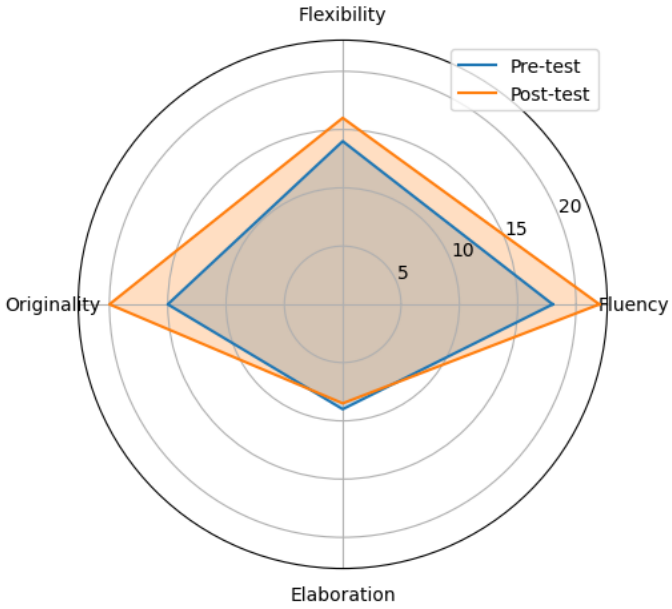
Dimension	Mean Pre (SD)	Mean Post (SD)	t (84)	p	Cohen's d
Fluency	17.85 (3.92)	21.94 (4.65)	8.24	<.001	0.74
Flexibility	13.92 (3.15)	16.08 (3.82)	6.12	<.001	0.58
Originality	15.12 (4.45)	19.96 (5.08)	9.95	<.001	0.90

Dimension	Mean Pre (SD)	Mean Post (SD)	t (84)	p	Cohen's d
Elaboration	8.85 (2.75)	8.58 (2.90)	-1.10	.284	-0.12
Total	55.74 (10.1)	66.56 (12.4)	10.15	<.001	0.88

Note. *SD* = standard deviation; *CI* = 95% confidence interval; *t* = Student's -statistic for related samples; *d* = effect size (Cohen's). Effect sizes are interpreted as: 0.20 (small), 0.50 (medium), and > 0.80 (large). $p < .001$.

Figure 2 represents the creative profile of the participants before and after the intervention using a radar chart (or spider plot) that overlays the mean scores of the TTCT dimensions. This allows for an integrated visualization of the creative pattern, facilitating a global comparison of the intervention's impact on each component. This reinforces the results obtained in the Student's t-test for related samples (Table 2), providing a synthetic overview of the transformative effect of the intervention on the overall creative profile.

Figure 2. Creative profile *Pre-test* and *Post-test* across TTCT dimensions



The *Pre-test* polygon appears more concentrated toward the center of the chart, reflecting a more homogeneous initial creative profile. In contrast, the *Post-test* polygon shows a clear expansion, which is particularly marked in the dimensions of *originality* and *fluency*, indicating a substantial increase in the capacity to generate novel ideas and in the quantity of responses produced following the intervention. The *flexibility* dimension also presents a noticeable expansion, albeit of a smaller magnitude, suggesting improvements in the ability to switch perspectives or conceptual categories. Conversely, the *elaboration* dimension maintains a practically stable profile between both points, consistent with the absence of statistically significant differences observed in the inferential contrast. The asymmetrical configuration of the *Post-test* polygon demonstrates that the intervention did not produce a uniform effect across all dimensions, but rather a differential impact, preferentially enhancing those components most directly linked to divergent thinking.

3.3. Motivational mediation and variance

The results of the analysis of variance and the correlation matrix (Table 6) reveal that the increase in creative potential is not an isolated phenomenon but is deeply mediated by an affective and social ecosystem. The repeated measures ANOVA confirms the robustness of the intervention, indicating that the time factor explains 32% of the variance in total creative change $n_p^2 = .32$, $p < .001$).

Table 6. Pearson correlations between affective variables and creativity (*Post-test*)

Variable	1	2	3	4
1. Total Creativity	—			
2. Intrinsic Motivation	.70**	—		
3. Perceived Autonomy	.58**	.62**	—	
4. Perceived Collaboration	.64**	.55**	.48**	—

Note. ** $p < .01$.

In analyzing the bivariate associations, a strong positive correlation is identified between *total creativity* and intrinsic motivation ($r = .70$, $p < .01$). This finding constitutes the explanatory core of the intervention: inherent enjoyment and personal interest in the task acted as the primary engine of creative cognition. This result is fully consistent with the dynamic model of Amabile and Pratt (2016), which posits that intrinsic motivation is the critical variable allowing students to persist in seeking novel and meaningful solutions to complex problems.

Furthermore, significant associations are observed between creativity and *perceived autonomy* (r = .58, p < .01) as well as *perceived collaboration* ($r = .64$, $p < .01$). According to Self-Determination Theory (Deci & Ryan, 2000), these data suggest that when the pedagogical environment satisfies the basic psychological needs for autonomy and social relatedness, creative engagement is enhanced. The close internal relationship between autonomy and intrinsic motivation (r = .62, p < .01) reinforces this interpretation. The fact that students could make real decisions regarding the design and corporal expression of their city generated a sense of ownership that triggered their interest in innovating. Additionally, the role of collaboration as a creative catalyst (r = .64) highlights that the transdisciplinary design fostered a climate of psychological safety and dialogue essential for the emergence of originality.

This evidence indicates that the success of the proposal did not reside solely in technical training, but in the construction of a classroom climate that transformed the students' perceptions of competence and autonomy into tangible creative results. Figure 3 presents a heatmap of Pearson correlations between creativity and the motivational variables evaluated in the *Post-test*. The chromatic intensity, ranging from cool to warm tones, allows for the visual identification of the magnitude of these associations.

When analyzing bivariate associations, a strong positive correlation is identified between *total creativity* and *intrinsic motivation* ($r = .70$, $p < .01$). This finding constitutes the explanatory core of the intervention: inherent enjoyment and personal interest in the task acted as the primary engine of creative cognition. This result is fully consistent with the componential model of creativity by Amabile and Pratt (2016), which posits that intrinsic motivation is the critical variable allowing students to persist in seeking novel and meaningful solutions to complex problems. Furthermore, significant associations are observed between creativity and *perceived autonomy* ($r = .58$, $p < .01$) as well as *perceived collaboration* ($r = .64$, $p < .01$). According to Self-Determination Theory (Deci & Ryan, 2000), these data suggest that when the pedagogical environment satisfies basic psychological needs for autonomy and social relatedness, creative engagement is enhanced. The close internal relationship between autonomy and intrinsic motivation ($r = .62$, $p < .01$) reinforces this interpretation. The fact that students could make real decisions regarding the design and corporal expression of their city generated a sense of ownership that triggered their interest in innovating. Additionally, the role of collaboration as a creative catalyst ($r = .64$) highlights that the transdisciplinary design fostered a climate of psychological safety and dialogue essential for the emergence of *originality*.

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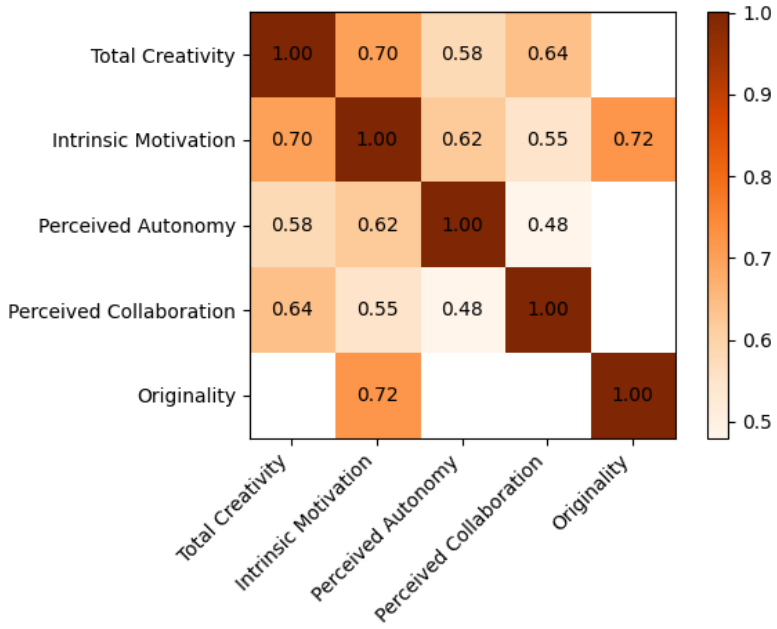
Figure 3. Heatmap of Pearson correlations between creativity and motivational variables in the *Post-test*.



Note. The color intensity reflects the magnitude of the Pearson correlation coefficient (*r*), where darker tones indicate stronger positive associations.

The results show that *intrinsic motivation* maintains the highest relationship with *total creativity* (r = .70, p < .01) and, most notably, *with originality* (r = .72). This association, represented by the most intense tones on the map, confirms that enjoyment of the creative process and personal involvement constitute the primary engine of original thinking within the performance context. Furthermore, total creativity is significantly related to *perceived autonomy* (r = .58) and perceived collaboration (r = .64), suggesting that learning environments promoting self-determination and social interaction jointly foster creative development. The relationship between *perceived autonomy* and *intrinsic motivation* (r = .62) reinforces this interpretation, pointing toward an integrated motivational ecosystem. All of this supports the hypothesis of motivational mediation in creative change, complementing the results of the repeated measures ANOVA. Taken together, it is evident that innovation does not emerge solely from technical training, but fundamentally from intrinsic commitment and the perception of freedom and collaboration during the creative process.

3.4. Process triangulation

The triangulation of the quantitative findings with the narrative evidence, systematized in Table 7, allows for the clarification of the mechanisms underlying the so-called “elaboration paradox.”

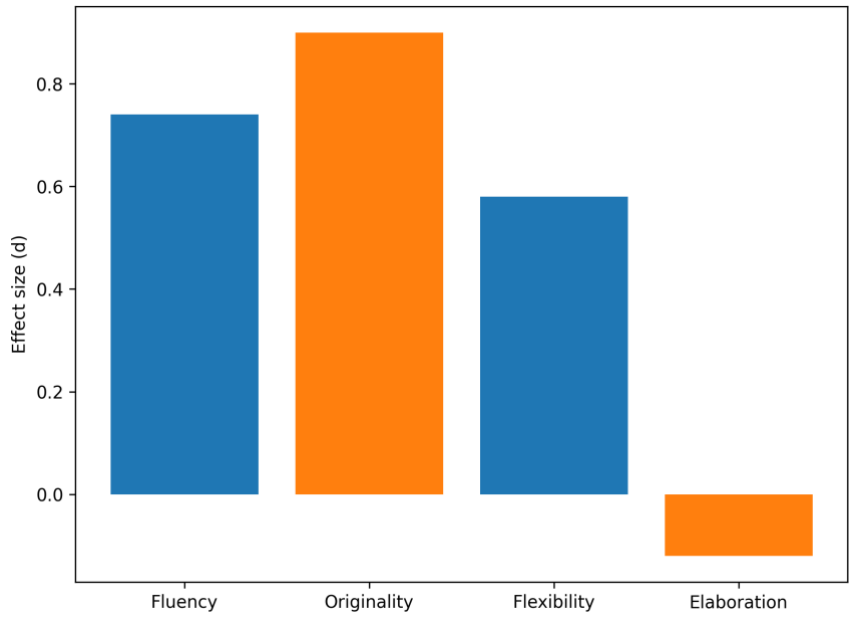
Table 7. Joint display of mixed methods integration

Dimension	Statistical Result	Qualitative Evidence	Meta-inference
Fluency	Increase (d = 0.74)	"We had to think of ten ways to move before choosing one."	Open inquiry forced ideational productivity.
Originality	Increase (d = 0.90)	Models with biomimicry and levitating buses.	Embodied learning allowed for unusual metaphors.

Dimension	Statistical Result	Qualitative Evidence	Meta-inference
Flexibility	Increase (d = 0.58)	"We changed the design when we saw the social map."	Urban reality forced category changes.
Elaboration	Stability (d = -0.12)	"We didn't paint everything to test if the circuit worked."	Attention economy (trade-off): functional priority over aesthetics.

Figure 4 displays the effect sizes associated with the changes observed across the different dimensions of creative thinking following the intervention. Moderate to high magnitude increases are identified in *fluency* (d = 0.74), *flexibility* (d = 0.58), and especially in *originality* (d = 0.90), indicating a substantive impact of the pedagogical approach on the generation, diversification, and uniqueness of the ideas produced.

Figure 4. Effect sizes (Cohen's *d*) across creative thinking dimensions following the *intervention*.



Note. According to standard reference criteria, values of 0.20, 0.50, and 0.80 are considered small, medium, and large effects, respectively.

In contrast, the *elaboration* dimension presents an effect size close to zero and slightly negative (d = -0.12), suggesting stability in this skill despite the improvements observed in the other creative processes. This differential pattern points to a functional dissociation between ideational expansion and the detailed refinement of proposals. From an integrative perspective, this quantitative configuration supports the so-called "elaboration paradox", which is further clarified by qualitative evidence. While open-ended inquiry and embodied or grounded learning boosted productivity and originality, participants prioritized functionality and rapid experimentation over aesthetic finish, generating an economy of attention between *exploration* and *elaboration.*

4. Discussion

The objective of the present research is to analyze the impact of a pedagogical intervention designed through the hybridization of Physical Education, Social Sciences, and Spanish Language on the development of creative thinking in fifth-grade Primary Education students. The findings, derived from a *Pre-Post* analysis using the Torrance Test of Creative Thinking (TTCT) and adapted motivation scales, not only corroborate the proposed hypotheses but also illuminate the

profound cognitive and pedagogical mechanisms underlying classroom innovation. The analysis aims to contrast the results with existing scientific literature, organized around the core pillars of embodied cognition, the restructuring of semantic memory, the dynamics of STEAM systems, and motivational mediation. It is argued that breaking down disciplinary compartmentalization and integrating the body and movement into the learning process act as critical catalysts for transitioning from a reproductive education toward a generative education, aligned with international mandates for the 21st century.

The most significant finding of this study lies in the substantial increase in the Originality dimension, which experienced a very large effect size (d = 0.90). This result significantly exceeds the moderate effects reported in recent meta-analyses on creative training programs in primary education (Ruiz del Pino et al., 2022), where effect sizes typically range between d = 0.50 and d = 0.60. The magnitude of this change suggests that the intervention was not limited to improving technical skills, but instead induced a qualitative transformation in the way students access and process information to generate novel ideas. Unlike traditional approaches that position creative thinking as an exclusively cerebral and computational process, the results of this intervention validate the premise that the mind is inexorably linked to sensorimotor experience. Authors such as Almarcha et al. (2022) have demonstrated that "embodied transdisciplinary education" facilitates the understanding of abstract and systemic concepts through physical experience. In their research, the use of body movement allowed students to understand principles of Dynamic Systems Theory (DST), achieving a deep and meaningful transfer of knowledge. Similarly, in the present study, by asking students to translate abstract urban concepts (such as "flow," "density," or "barrier") into bodily metaphors and choreographies, a process of intersemiotic transduction was activated (Table 8).

Table 8. Summary of the mechanisms of embodied or grounded cognition and their empirical manifestation in intervention

Observed Cognitive Mechanism	Theoretical Foundation	Evidence in Current Study
Intersemiotic Transduction	Translation of verbal codes to motor codes stimulates plasticity.	Conversion of urban problems into acrosport and dance.
Cognitive Offloading	The body releases working memory resources for innovation.	Greater capacity to propose complex architectural designs (originality d = 0.90).
Conceptual Metaphor	Movement grounds the understanding of abstract concepts.	Use of "motor skills circuits" to understand transport flows.

This process forces the student to "unpack" the semantic meaning of a concept and "repackage" it into a different modality (kinesthetic). According to Castro-Alonso et al. (2024), this multimodal manipulation and the use of gestures and movements not only result in cognitive offloading, reducing the burden on working memory, but also enrich mental representations, allowing for the emergence of unusual associations, which are the basis of originality. The results validate the proposal by Wren et al. (2022) regarding "embodied or grounded creative pedagogies" in STEAM contexts. These authors argue that creativity is not an isolated individual skill, but an emergent phenomenon of the "embodied dialogue" between the student, their peers, and the material environment. In the intervention, the design phase and the final "urban performance" were not mere presentations but acts of material inquiry. By constructing models with recycled materials and designing movement routes, the students entered into a dialogic relationship with space and matter. Wren et al. (2022) argue that this material-discursive approach allows for overcoming the limitations of traditional psychological creativity, fostering a deeper agency and an affective connection with the object of learning. The high *originality* index observed indicates that when students are allowed to physically explore

the possibilities of "being" a city before designing it, the resulting solutions escape standard visual clichés (square houses, straight streets) to embrace organic, dynamic, and systemic forms.

On the other hand, the significant increase in the dimensions of *fluency* (d = 0.74) and *flexibility* (d = 0.58) suggests an improvement in the efficiency of information retrieval processes and the ability to switch cognitive strategies when facing complex problems. To understand the nature of this change, it is pertinent to refer to the recent findings of Lai et al. (2024). In their study on how science education fosters creativity, they discovered that successful interventions "reshape" students' semantic memory. Specifically, they observed that creative training increases the interconnectivity between distant concepts, creating semantic networks with "small-world" properties, characterized by short paths between information nodes and lower modularity. In the context of the intervention carried out, *fluency* should not be interpreted simply as "more ideas," but as greater accessibility to an enriched semantic network. The hybridization of disciplines (Social Sciences + Physical Education + Language) likely acted as a "cross-pollination" mechanism, establishing new neural bridges between previously isolated domains (e.g., linking "kinetic energy" from P.E. with "sustainable transport" from Social Sciences). This cognitive restructuring explains why students were able to generate a higher volume of responses in the *Post-test*. By reducing the semantic distance between disparate concepts (body-city, movement-structure), the activation threshold for retrieving ideas decreased, facilitating a more torrential flow of ideas.

Flexibility, understood as the variety of conceptual categories used, was enhanced by the rotating and multifaceted nature of the tasks. By requiring students to adopt multiple roles (architect, dancer, sociologist, writer), the intervention explicitly trained *cognitive flexibility*. According to cognitive flexibility theory discussed in educational neuroscience contexts, the ability to switch perspectives (*set-shifting*) is essential for creativity. The fact that flexibility showed a moderate-to-high effect (d = 0.58) indicates that students learned to inhibit their dominant responses (obvious solutions) and explore alternative categories. This result is consistent with the findings of Almarcha et al. (2022), who found that embodied education improves "far transfer," allowing principles learned in a motor context to be applied to abstract cognitive problems. An intriguing and seemingly contradictory finding was the stability of the *elaboration* dimension (d = -0.12), which showed no significant improvement following the intervention. Far from invalidating the program's success, this data offers a valuable window into understanding the economy of cognitive resources in Project-Based Learning (PBL). Classic and contemporary literature on creativity assessment, from Torrance (2008) to Soto et al. (2015), recognizes that the dimensions of *creativity* do not always covary positively. There is a well-documented phenomenon of attention economy (trade-off or compensation). When a task demands a high level of novelty (*originality*) and systemic restructuring (*flexibility*), attentional and working memory resources focus on generating the core of the idea, reducing the capacity for detailed and ornamental refinement (*elaboration*). The model by Kaufman and Beghetto (2009) on classroom creativity emphasizes that creativity is an interaction between *originality* and *task appropriateness*.

In our study, students faced highly complex design problems (e.g., "how to design a car-free city?"). Solving this problem required a massive cognitive effort to imagine novel functional systems. It is likely that, under the pressure to innovate structurally, students sacrificed superficial aesthetic detail in the Torrance test, prioritizing the communication of the core idea over its ornamentation. This finding suggests that in STEAM interventions that prioritize systems thinking and problem solving, traditionally measured *elaboration* (such as the number of details added to a drawing) might not be the most sensitive indicator of creative quality. As Perignat and Katz-Buonincontro (2019) point out, there is a risk that activities are evaluated superficially if the underlying deep learning processes are not considered. The stability in *elaboration* could, paradoxically, be interpreted as a sign of cognitive efficiency. Students learned to prototype rapidly and communicate the functional essence of their proposals, an influence of the Design Thinking mindset implicit in the project, rather than getting lost in a "pretty" graphic. This aligns with observations by Soto et al. (2015), who warn of the need for rubrics that distinguish between decorative richness and structural complexity.

The findings of this research provide critical evidence to the debate regarding the nature of the STEAM perspective. While many implementations focus strictly on technology and engineering (robotics, programming), our study demonstrates the power of integrating the Social Sciences and Humanities (Language) as the fundamental backbone. The integration of Social Sciences provided both context and purpose to creativity. Following Danielson et al. (2022), the integration of arts and sciences is most effective when it facilitates systems thinking. In their study, they found that art helped students visualize interconnections within biological ecosystems. Parallel to this, in our intervention, the social analysis of the city (neighborhoods, inequalities, flows) provided the "raw material" upon which creativity operated. Without this social component, creativity risks becoming an empty aesthetic exercise. By anchoring design in real-world problems (sustainability, coexistence), the program fostered what Perales and Aróstegui (2021) term a "social and democratic" conception of STEAM education, which moves beyond economic rationality to embrace a humanistic vision. These results validate the criticisms of curricular fragmentation presented in the introduction. The global improvement in the *creativity* index (d = 0.88) supports the thesis that compartmentalization into subjects limits cognitive potential. Aguilera and Ortiz-Revilla (2021), in their systematic review of STEM/STEAM and *creativity*, conclude that integrative approaches are superior for developing 21st-century skills, though they warn of the heterogeneity in implementations. This study offers a replicable model for such integration, not through the mere juxtaposition of content, but through transdisciplinary concepts (space, flow, structure) that are explored simultaneously through the body (Physical Education), society (Social Sciences), and narrative (Language).

The strong correlation found between *intrinsic motivation* and total *creativity* (r = .70) confirms that affective factors are indispensable precursors to cognitive performance. Analyzing these data through the lens of Self-Determination Theory (Deci & Ryan, 2000), the project design satisfied the basic psychological needs of *autonomy*, *competence*, and *relatedness*. The correlation between *perceived autonomy* and *creativity* (r = .58) is particularly revealing. By allowing students to make real decisions about their city's design (agency), a sense of ownership was generated which, according to Amabile and Pratt (2016), is essential for both organizational and individual creativity. The dynamic componential model of creativity (Amabile & Pratt, 2016) posits that *intrinsic motivation* is the "fuel" that enables individuals to persist in seeking novel solutions when faced with difficulty. In our intervention, the inherent enjoyment experienced by students during motor exploration and role-playing acted as a buffer against the frustration inherent in complex problems, allowing them to maintain high levels of engagement. Furthermore, the association between *perceived collaboration* and *creativity* (r = .64) highlights the social nature of innovation. Contrary to the myth of the solitary genius, these results support the sociocultural view that creativity emerges from interaction. As Moreno-Murcia et al. (2011) point out within the spanish context, satisfying the need for relatedness is a strong predictor of self-determined motivation. Teamwork, used to build models and coordinate choreographies, created a "community of practice" where ideas were refined through debate and negotiation, a key process also described by Wren et al. (2022) as "material dialogue."

The findings of this research transcend the classroom to engage in dialogue with global guidelines on the future of education. The UNESCO (2021) report "Reimagining our futures together" advocates for a new social contract that prioritizes cooperation, creativity, and solidarity. This study operationalizes this vision, demonstrating that it is possible to build a curriculum that fosters cognitive excellence without sacrificing well-being or equity. By integrating the ethics of care (through urban sustainability) with technical innovation, the program responds to UNESCO's call to educate for "just and sustainable futures." Furthermore, the results align with the OECD's (2019) "Learning Compass 2030", which identifies "*creating new value*" as a key transformative competency. The students' ability to reimagine their urban environment demonstrates that school can be a space for developing student agency and the capacity to navigate uncertainty. The intervention proved that Physical Education, far from being peripheral, is central to the development of "physical and mental well-being," which the OECD itself positions as the foundation of learning.

Despite the robustness of these findings, we encountered certain limitations in the study. The single-group quasi-experimental design, while ecologically valid, limits the control over extraneous variables. However, the consistency of the results with the literature on embodied cognition (Almarcha et al., 2022) and semantic networks (Lai et al., 2024) reinforces internal validity. Future research should employ mixed designs with active control groups and longitudinal measures to evaluate the long-term persistence of creative effects. Furthermore, it would be pertinent to explore whether the phenomenon of economy of attention in elaboration remains if digital assisted design tools are introduced, or if it is an inescapable cognitive constant in early developmental stages. Below is a synthesis that relates the empirical results of the study to the reference theoretical frameworks used (Table 9).

Table 9. Theoretical frameworks

Dimension	Result (d / r)	Main Theoretical Connection	Interpretation in light of Literature
Originality	0.90 (high)	Embodied cognition (Almarcha et al., 2022; Castro-Alonso et al., 2024).	Bodily movement facilitates novel conceptual metaphors and the breaking of stereotypes.
Fluency	0.74 (high)	Semantic networks (Lai et al., 2024).	The intervention reorganizes semantic memory creating more interconnected "small-world" networks.
Flexibility	0.58 (medium)	Transdisciplinarity (Aguilera & Ortiz-Revilla, 2021).	The rotation of STEAM roles trains cognitive set-shifting.
Elaboration	-0.12 (null)	Cognitive trade-off (Beghetto & Kaufman; Torrance).	Systemic complexity forces the prioritization of novelty over aesthetic detail.
Motivation	r =.70 (strong)	Self-determination theory (Deci & Ryan, 2000; Amabile & Pratt, 2016).	Autonomy and social purpose are mandatory precursors of high-level creativity.
Systemic Impact	Global	Educational systems (UNESCO, 2021; OECD, 2019).	Empirical validation of transformative competencies and holistic education.

5. Conclusion

The research findings lead to the conclusion that the transdisciplinary integration of Physical Education, Social Sciences, and Spanish Language constitutes a highly effective pedagogical response for overcoming traditional disciplinary silos in Primary Education. The results demonstrate that it is possible to reconfigure the students' cognitive profiles toward levels of creative excellence, validating a model that transcends the purely technical vision of conventional STEAM approaches.

First, it is confirmed that the body, far from being a mere physical support, acts as a fundamental epistemological mediator in the learning of complex systemic concepts. The massive increase in the dimensions of *originality* (d = 0.90) and *fluency* (d = 0.74) provides evidence that embodied learning (physical experience) allows students to access sensorimotor metaphors that facilitate the generation of unusual and novel solutions. This finding refutes the mind-body dualism prevalent in the school curriculum and positions motor skills as a driver of abstraction and cognitive flexibility. Secondly, the stability observed in the *elaboration* dimension should not be interpreted as stagnation, but rather as a manifestation of the phenomenon of economy of attention or cognitive load. In real-world problem-solving contexts mediated by image and movement, students strategically prioritize structural viability and the conceptual novelty of the creative core over peripheral ornamental detail. This process of cognitive optimization suggests that the development of scientific and social creativity requires maturation periods that capture the depth of inquiry rather than final technical polish. Furthermore, the research concludes that creativity is a socially situated and emotionally mediated phenomenon. The strong correlation detected between intrinsic motivation and total creative performance underscores that educational success depends on creating a classroom climate that satisfies the needs for autonomy and competence. By providing innovation with an

ethical and social context through Social Sciences, a "cultural intelligence" is fostered that transforms aesthetic production into an act of civic commitment.

This study provides empirical evidence in favor of a new social contract for education proposed by organizations such as UNESCO. Creativity is not a mystical gift, but a trainable competence that flourishes when the walls between mind and body, and between school and city, are torn down. In this scenario, Physical Education, in alliance with the arts and social sciences, emerges as a cornerstone discipline for the formation of a critical, creative, and embodied citizenship. The results suggest that to prepare future generations for the uncertainty of the digital age, schools must become laboratories of embodied and visual experiences. Breaking down the barriers between subjects is not only a didactic strategy but an ontological imperative to form citizens capable of visualizing, designing, and building sustainable solutions in a society in constant transformation.

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