

Fostering Creativity Through Meta Virtual Project-Based Networked Learning: An In-Depth Examination

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Abstract: This research explores the effectiveness of Meta Virtual Project-Based Networked Learning (Meta VPNL) in fostering student creativity in a fully digital, project-based environment. In the context of 21st-century education, creativity has become an essential skill, driving both economic progress and social innovation. However, traditional education systems often prioritize rote learning and standardized testing, leaving little room for creative exploration. This study investigates how integrating digital tools and collaborative virtual learning can overcome these constraints, thereby offering a more dynamic learning model that promotes creative thinking across domains. The Meta VPNL model was designed to create a flexible, collaborative, and interdisciplinary project environment where students can engage with real-world problems, generate novel ideas, and refine their creative processes. Using an explanatory sequential mixed-methods design, the study combines quantitative and qualitative approaches to assess the impact of the Meta VPNL model on creativity. The quantitative phase involved pre- and post-tests using the Torrance Tests of Creative Thinking (TTCT), assessing four core dimensions of creativity: originality, fluency, flexibility, and elaboration. The qualitative phase included interviews and participant observations to gain deeper insights into student experiences, perceptions, and challenges during the learning process. Results from the study reveal a significant improvement in student creativity across all four dimensions, with fluency and originality showing the most substantial gains. Furthermore, the research highlights the role of prior experience in digital project-based learning, where students with higher levels of prior experience demonstrated enhanced creative performance. Despite the positive outcomes, challenges such as technical issues, inadequate hardware, and group dynamics in virtual settings were reported. However, students were able to overcome these obstacles through collaborative efforts, peer support, and adaptive problem-solving strategies. This study demonstrates that the Meta VPNL model is an effective pedagogical strategy for nurturing creativity in the digital age. It offers valuable insights for educators aiming to integrate technology-driven, project-based learning in classrooms, paving the way for more creative, engaged, and self-directed learners.

Keywords: Creativity, Meta virtual project-based networked learning, Artificial intelligence for learning, Quality education

1. Introduction

In the twenty-first century, scholars and policy-makers alike now agree that creativity drives economic growth and social progress, making its deliberate inclusion in school curricula a pressing concern (Ridwan, Rahmawati, Hadinugrahaningsih, 2021; S.Anagun, 2018). Yet many standard school programs still lean heavily on rote learning and high-stakes tests, leaving little room for students to experiment, daydream, or craft original ideas of their own (Dilekçi and Karatay, 2023). With technology rapidly altering how lessons are planned and delivered, educators are called not only to use digital tools but also to design classroom experiences that spark and sustain creative thought. Recent evidence from a range of educational contexts points to a critical need for persistent attention to creativity, revealing enduring obstacles such as teachers misinterpreting what creative thinking entails (Hashim and Damio, 2023, Mu-dan and Cai, 2020), structural barriers in online learning environments (Mu-dan and Cai, 2020), and the absence of inclusive and formative assessment frameworks (Veber, Pesek, Aberšek, 2023). Therefore, the urge practitioners to build adaptable classrooms, weave creative-process skills into daily tasks, and sustain a habit of reflective evaluation within and outside the lesson (Egwutvongsa, 2023). Creativity dimensions-fluidity, flexibility, originality and elaboration-demand explicit room in curriculum planning, yet even tightly sequenced subjects like mathematics can invite innovative thinking when tasks are framed to question norms and broaden students horizons, while disciplinary learning, such as mathematics, can be reimagined to challenge and expand students' creative perceptions (Aziz and Bakar, 2021; Lubna, Suhirman, Prayogi, 2024). Despite these advancements, fostering creativity remains a complex endeavor that requires sustained innovation in instructional methods and cross-contextual inquiry.

In today's fast-moving digital age, almost every breakthrough—from new gadgets to social apps—depends on creative thinking. Despite this, many schools still favour rote drills and uniform exams, squeezing imagination out of the routine. Project-based learning (PjBL) steps in as a clearly student-centred answer to that gap. By letting small groups tackle genuine, timed problems, PjBL shifts lessons from quick reviews to serious investigations. Learners therefore master core material while building critical, team, self-management, and creative skills employers now expect.

The advantages of PjBL across different educational settings are magnified when digital technology is woven into the process. Research indicates that a blended PjBL model boosts learners' grammar, comprehension, and vocabulary, resulting in more fluent speaking performance (Hoesny, Setyosari et al., 2024), raises future teachers' awareness of responsible online behaviour (Gu, Ritter et al., 2021), and even shifts educators' views of their responsibilities in a networked world (Avidov-Ungar and Tsybulsky, 2021). Beyond these immediate gains, technology-rich PjBL cultivates both technical and metacognitive competencies that employers increasingly demand from graduate workers (Rohm, Stefl, Ward, 2021), broadens equitable access to scientific content (Fitzgerald and Evans, 2024), uplifts prospective vocational educators' mastery of digital tools (Setuju, Triyono et al., 2024), and sharpens students' overall writing proficiency (Irwandi, Bafadal et al., 2024). Within pre-service teacher programmes, instructors commonly rely on learning-management systems and social-media platforms; nevertheless, research consistently emphasises that careful, ongoing teacher guidance is what ultimately transforms good design into meaningful student learning outcomes (Rahmawati, Suryani et al., 2020). Taken together, these findings portray digitally enriched PBL as a relevant, flexible, and powerful pedagogical strategy for equipping learners with the skills they need to thrive in an increasingly digital age.

Yet, even with its proven advantages, classroom-based project work continues to face challenges related to distance, costs, and uneven access to tools. In response, Meta Virtual Project-Based Networked Learning reimagines the approach in a wholly online setting. By using digital platforms, the model enables nimble, far-reaching collaboration that can occur anytime, anywhere, well beyond the walls of any single school.

The study aims to provide both theoretical insight and practical guidance for designing project-based digital learning environments that genuinely enhance student creativity. Accordingly, it will evaluate how the proposed Meta Virtual Project-Based Networked Learning (Meta-VPNL) model influences four core creative dimensions—originality, fluency, flexibility, and elaboration—and measure the resulting creative performance in a fully virtual classroom. Researchers also aim to document learners' experiences and the obstacles they confront while working online so that educators have a richer, firsthand account of the model's everyday operation. Collectively, the data should clarify how purposeful technology use, responsive instructional design, and peer-centered online collaboration combine to cultivate creative and other essential twenty-first-century skills. From these findings, practical recommendations will emerge, guiding universities toward more relevant, forward-thinking pedagogies that align with the digital era. To fulfill this agenda, the inquiry is framed around three interrelated research questions:

RQ1: To what extent is the Meta VPNL model effective in enhancing student creativity based on the four dimensions of creativity (originality, fluency, flexibility, and elaboration)?

RQ2: How do students' experiences and perceptions of the Meta VPNL model shape their creative development, and how do the challenges encountered affect their learning outcomes?

2. Literature Review

2.1 Creativity in Education

Creativity in education is widely acknowledged as a vital skill, yet it lacks a single, universally accepted definition. Foundational scholars have offered influential perspectives: Torrance views creativity as a process involving the generation of original ideas through divergent thinking, while Guilford emphasizes cognitive aspects such as originality and fluency within problem-solving contexts (Aziz and Bakar, 2021, Gültepe, Akben et al., 2025). Meanwhile, highlights the central role of intrinsic motivation, asserting that creativity flourishes when individuals are genuinely engaged and self-driven (Mejía, D'Ippolito, Kajikawa, 2021). These perspectives converge on four key dimensions commonly used to describe creativity: originality (the uniqueness of ideas), fluency (the quantity of ideas), flexibility (the ability to shift thinking approaches), and elaboration (the depth and detail in ideas) (Fatmawati, Jannah, Sasmita, 2022; Hendrik, Ali et al., 2022). In the context of 21st-century education, creativity is considered a core competency essential for preparing students to navigate complex, fast-changing environments, particularly in fields such as STEM, where innovation, adaptability, and collaboration are paramount (Rahimi, Smith et al., 2024, Yang, 2023).

The cultivation of creativity, therefore, encounters several systemic hurdles. Most school systems, long accustomed to ranking students, lean heavily on standardised tests and memorisation; practices that routinely sweep over deeper, more inventive thinking (Can and Burakgazi, 2022, Zemljak and Vrtič, 2022). Compounding this, many teachers have not been prepared in creative methods, so what little innovation does appear in classrooms is patchy and unreliable (Constant, Friston, Clark, 2023; Roth, Conradty, Bogner, 2021). Moving past these blockades requires deliberate reform that weaves creativity into curricula and provides educators with the ongoing training they need to cultivate it with confidence. At its heart, creativity blends originality, fluency, flexibility and elaboration—a blend universities now see as vital to success in a fast-changing world.

2.2 The Need of Creativity Skills in the 21st Century for Learners

In *21 Lessons for the 21st Century*, Yuval Noah Harari underscores the growing centrality of creativity as the quintessential human faculty in an era increasingly dominated by automation. Harari contends that as algorithms and robotics transform entire economies by displacing jobs built upon repetition, the singular human aptitude for inventive thought emerges as the principal site of competitive advantage (Harari, 2019). Increasingly, routine operations that once demanded human labour now yield to more efficient machines, thereby rendering the cultivation of imaginative and unconventional problem-solving capacity imperative (Dilekçi and Karatay, 2023). Creativeness, in Harari's view, is not reserved for the conventional arts alone; it is equally demanded of every professional sphere in which obstacles are novel, requisite adaptation is immediate, and the pace of external change is relentless. He suggests that the power to innovate will prove decisive in confronting the intricate, contingent challenges of a society in ceaseless, rapid flux, with special reference to domains such as medicine, engineering, corporate strategy, and civic advancement.

Harari's analysis parallels a broader international discourse advocating for expanded creativity learning in educational settings. Rapidly accelerating technological upheaval has rendered static instructional regimes anchored in memorisation, time rigidity, and uniform evaluation fundamentally inoperative for foresighted social planning (Harari, 2019). Consequently, all education systems face an imperative of purposeful transformation. The author's prognosis posits that future learning environments will centre on competencies in creative and critical cognition, capacities deemed indispensable for adaptive citizenship in an unpredictable, algorithmic economy. To Harari, imaginative agility transcends vocational preference; it constitutes a generalised competency requisite for deciphering multifaceted contemporary challenges. Consequently, contemporary classrooms must recalibrate away from hierarchically ordered, imitation-transmission sequences that explicitly sanction intellectual conformity (Fourniyati, Nuswowati, Cahyono, 2020; Gu, Ritter et al., 2021). Educators are charged instead with cultivating iterative, inquiry-based paradigms that incentivise experiential discovery, collaborative inquiry, and responsible creative experimentation.

This vision aligns with contemporary educational reform initiatives that advocate the deliberate cultivation of creative thinking across all curricular domains, from STEM fields to the humanities. Increasingly, stakeholders urge schools to offer sustained, open-ended investigations, interdisciplinary courses, and collaborative, problem-based learning experiences, each of which is designed to activate and amplify the latent creative capacities of all learners (Harari, 2019). Harari's scholarship underscores that, for students to flourish in the 21st Century, the educational enterprise must move beyond the mere transmission of factual content to the deliberate cultivation of generative thought and innovative action. Such an evolutionary shift is not an optional enhancement, but a fundamental prerequisite for equipping the forthcoming cohort to navigate the multifaceted challenges and asymmetric opportunities that will define the coming epoch.

2.3 Project-Based Learning (PjBL) in Education Activities

Project-Based Learning (PjBL) positions learners at the centre of sustained, open-ended projects that resemble real-world issues, thereby connecting theoretical material to hands-on practice. Central to the model are student initiative, prolonged teamwork, and inquiry across weeks or months, as groups formulate compelling questions, investigate them, build, test prototypes, and step back to evaluate what worked and why (Budiarti, Johari et al., 2022; Melkonyan, Tanajyan, Khachatryan, 2024). Because each project typically draws on science, art, mathematics, and other disciplines, the experience does not feel contrived; instead, it unfolds as an authentic interdisciplinary narrative (Ridwan, Rahmawati, Hadinugrahaningsih, 2021). Multiple studies show that creativity flourishes under this structure: when students face loosely defined problems, they must generate and revise novel options, rather than reciting memorized steps (Mite, Eveline, Situmorang, 2021). Bell argues that the controlled space PjBL provides encourages learners to tinker with ideas, try different strategies, and fail productively, habits strongly associated with advanced cognitive processes (Almulla, 2020). Interpersonal

production reinforces mastery because explaining logic to teammates and conveying understanding through videos, reports, prototypes, or code both clarify an individual's knowledge and reveal gaps.

Framing projects within online platforms then maintains enthusiasm and broadens toolboxes for planning, recording and globally sharing work, amplifying authenticity, speeding feedback and encouraging iteration. In short, Project-Based Learning fosters creativity because it ties classroom tasks to fundamental questions and collaborative problem solving, which increases when instructors purposely integrate technology into the projects. Studies repeatedly show that this model lifts students' artistic capacities and overall interest in school, making it a promising tactic for the progressive classrooms of the future.

2.4 Meta Virtual Project-Based Networked Learning (Meta VPNL)

Meta-Virtual Project-Based Networked Learning builds on conventional project-based learning by situating all learning tasks in rich, shared online environments. New hardware and software tools across the education ecosystem provide constant connectivity, low-latency interaction, remote collaboration, and a persistent sense of virtual presence for students and instructors alike (Furniyati, Nuswowati, Cahyono, 2020; Sungkono and Ekaputra, 2023). Participants from different countries undertake interdependent activities, jointly refining research questions, prototype designs, and evaluation criteria through a single, unified suite of digital dashboards and applications. The entire experience rests on three banners: virtuality, which grounds the curriculum in an always-on simulated campus; connectivity, which links learners, mentors, and tools with cross-device, real-time messaging; and interactivity, which opens space for instant feedback, peer dialogue, and instructor coaching as each project milestone appears (Faridah, Salahudin et al., 2021, Khusnul, Sumarno et al., 2025).

Preliminary studies of networked learning indicate a consistent, positive link to creativity, with evidence suggesting that the collaborative framework of Meta VPNL can notably enhance learners' imaginative products (Khusnul, Rusijono, Andi, 2024). In a similar vein, Melisa and colleagues document that participants in networked project-based learning exhibit greater motivation and more inventive thought, attributing these gains to the broad array of viewpoints exchanged within the online community (Melisa, Nawahdani, Alam, 2024). Wangs review further asserts that such environments enrich the creative context by facilitating information sharing and sustained collaboration, cornerstones of innovative cognition (Wang, 2022). Because these virtual classrooms are flexible and fast-moving, they urge learners to test theories, tinker with tools, and confront problems under changing conditions, strengthening both digital skills and adaptive problem-solving (Wang, Tie et al., 2023). Collectively, this blend of responsive, technology-rich space and project-driven inquiry widens access to knowledge while cultivating critical reason, experimentation, and creative expression. Thus, Meta VPNL offers a forward-looking pedagogical model that integrates virtual teamwork with PjBL tenets, thereby laying a solid foundation for richer, more interconnected, and interactive learning experiences. A growing body of evidence now shows that when project-based work is paired with well-organised digital platforms, students gain in creative thinking (Ekayana, Parwati et al., 2025; Yustina, Syafii, Vebrianto, 2020). Still, few studies have used established tools such as the TTCT in online settings, leaving a gap in our overall picture of how models like Meta VPNL affect creativity. Hence, future work should not only measure Meta VPNL quantitatively but also connect these metrics to teaching strategies that foster exploration, collaboration, and reflection within a structured digital space.

2.5 Theoretical Framework

The theoretical framework behind Meta Virtual Project-Based Networked Learning (Meta VPNL) deliberately draws on a suite of established educational theories that illuminate the links between learning and creativity. Core constructivist ideas from Piaget and Vygotsky suggest that learners build knowledge most effectively when they engage actively with peers, artifacts, and social contexts (Alhassan, Akparep, Ngmenkpieo, 2022; Hashim and Damio, 2023). This view closely aligns with Meta VPNL's insistence that students tackle real-world problems in virtual spaces, a practice that makes learning purposeful, collaborative, and embedded in meaningful situations. Vygotsky's attention to dialogue and joint activity shows up in faculty-designed projects that cultivate a community of practice where peer-to-peer mentorship becomes routine (Rahayuningsih, Kamaruddin et al., 2024). Taken together, these strands argue that a well-structured, dynamic online environment enhances intrinsic motivation and, in turn, yields higher levels of creative output within the Meta VPNL model.

Networked Learning Theory backs the idea that online learning is first and foremost a social activity, a point made by Goodyear and Siemens and echoed in more recent studies (Kim, Grijalva et al., 2023, Malik, Nadeem et al., 2022). According to this framework, new ideas emerge not from solitary study but from the back-and-

forth exchanges among students, with technology acting as the bridge that connects distant locations and sparks collective creativity. The theory thus underpins the current investigation, which plans to measure student inventive thinking using both widely accepted tests and real-world assignments. By emphasizing interaction as the engine of online courses, Networked Learning Theory shows how learners co-build knowledge and freely experiment with solutions in varied settings. When viewed together, these insights make the Meta VPNL model appear to be a solid system for boosting creativity through guided teamwork and, crucially, through empowering students to take charge of their own learning journeys.

3. Method

3.1 Study Design

By embedding project-based teaching in persistent, collaborative, and networked digital contexts, Meta VPNL enhances it. Conventional teaching uses episodic lectures, inert texts, and isolated tasks to teach pupils without applying knowledge outside the classroom. Meta VPNL challenges students to solve real, complicated problems, form diverse international teams, and use digital tools like asynchronous forums and interactive modeling software to innovate and inquire. VPNL transforms subject mastery into systems thinking, invention, and negotiation, helping students synthesize information, create new replies, and criticize peer work. Importantly, the architecture embraces the unknowable difficulties of the 21st century, featuring an agile, multimodal classroom that can bridge disciplinary and temporal divisions and skills and scaffolding that will be instantly useful after the educational moment.

The research adopted an explanatory sequential mixed-methods design to assess how the model influences student creativity (McKim, 2017). In the initial quantitative phase, survey scores were collected and analyzed to measure shifts in four creativity dimensions: originality, fluency, flexibility, and elaboration. Following this, a qualitative phase used interviews and focus groups to explore learners' experiences and perceptions, thus clarifying and contextualizing the earlier numerical findings about their engagement with Meta VPNL activities (Leech and Onwuegbuzie, 2009).

3.2 Participants

The study drew its participants from the Audio/Radio Media Development course offered at the State University of Surabaya in Indonesia. Researchers chose this class because its design, which is completely centred on project-based learning, digital media production, and team assignments, aligns with the goals and tools of the Meta Virtual Project-Based Networked Learning (Meta-PVNL) model. In all, 184 students volunteered, coming from different classes but still the same department. Ethical approval was secured prior to the study, and all volunteers signed informed-consent forms confirming their willingness to participate (Asenahabi and Peters, 2023).

3.3 Intervention

In this study, researchers integrated the Meta Virtual Project-Based Networked Learning (Meta-VPNL) model into a virtual classroom to guide the instructional design. Working through the university's adapted Learning Management System, students took part in organized project activities that required them to collaborate across disciplines while addressing complex problems, with the platform intentionally modified to support four creativity dimensions: originality, fluency, flexibility, and elaboration. The model was rolled out in a sequenced manner: Needs Assessment & Goal Setting identified student and course requirements; Orientation Platform Virtual introduced relevant technologies; Project Planning structured tasks; Design & Implementation involved executing project work; Collaboration coordinated distributed teams; Assessment & Reflection guided formative evaluation; and, finally, Evaluation & Exhibition showcased results. As shown in Figure 1, each phase includes concrete subtasks that prompt idea exploration, online teamwork, and the creative application of knowledge to authentic challenges.

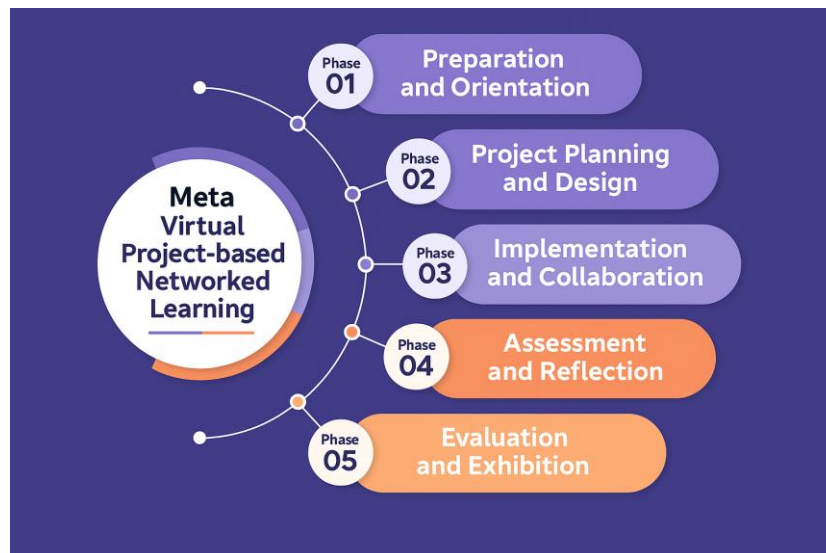


Figure 1: The Meta Virtual Project-based Networked Learning

Figure 2 presents detailed information on the Meta VPNL syntax. In sum, this orderly sequence of activities aims to develop students' creative skills within a digital, networked learning environment.

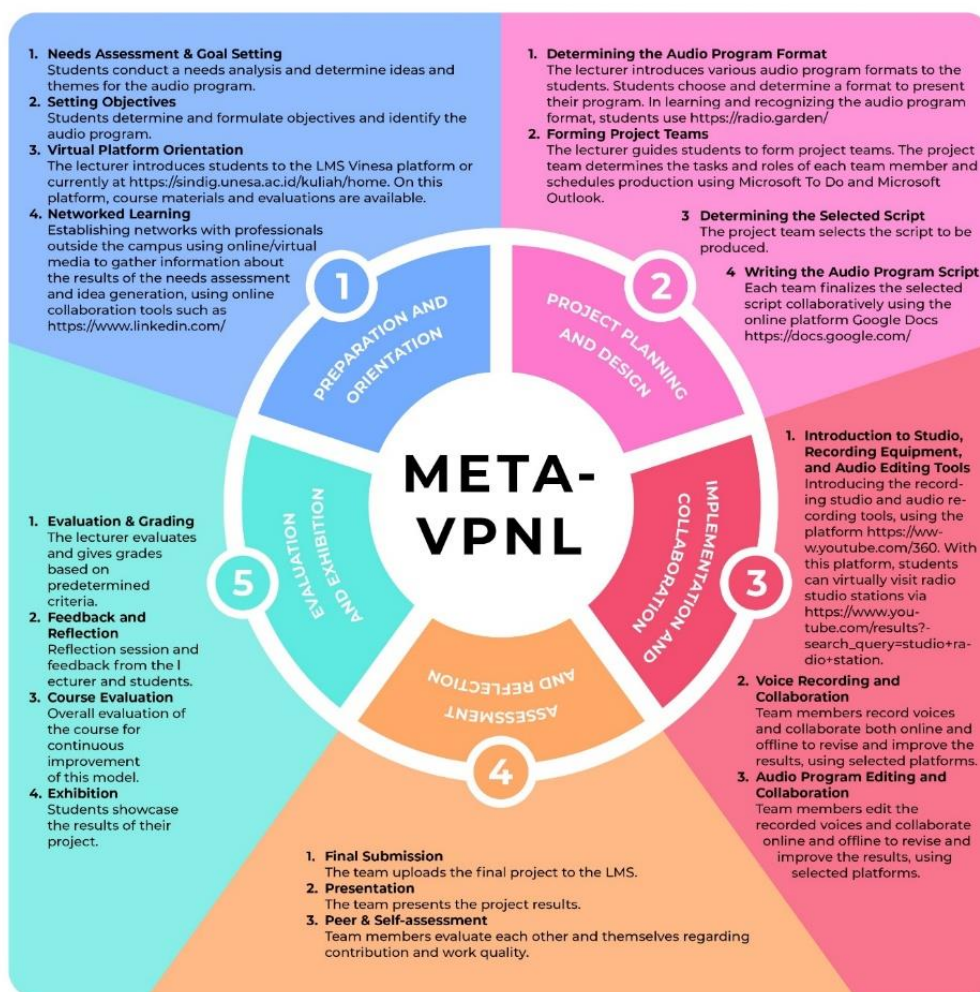


Figure 2: The Meta Virtual Project-based Networked Learning's Steps

3.4 Data Collection and Research Instrument

This study employed a combination of quantitative and qualitative instruments to comprehensively assess the impact of the Meta Virtual Project-Based Networked Learning (Meta VPNL) model on students' creativity.

Quantitative data were collected using two instruments. First, the Torrance Tests of Creative Thinking (TTCT) were administered in both pre-test and post-test formats to measure four key components of creativity: originality, fluency, flexibility, and elaboration. These components were assessed using standardized scoring guidelines provided by the TTCT manual. The rubric employed a four-level scale (novice to expert) for each assessed dimension. Prior to its full implementation, the rubric underwent expert review and a pilot test to ensure its content validity and reliability. The table 1 shows the instrument blueprint of Torrance Test of Creative Thinking (TTCT).

Table 1: Instrument Blueprint – Torrance Tests of Creative Thinking (TTCT)

No	Assessed Component	Operational Definition	Indicator	Instrument
1	Originality	Ability to produce unique or uncommon ideas	Unusual and original ideas that differ from the norm	TTCT
2	Fluency	Ability to produce a large number of ideas	The quantity of ideas generated within a given task	TTCT
3	Flexibility	Ability to shift perspectives or approaches to problem-solving	Range and variation in ideas within a given task	TTCT
4	Elaboration	Ability to develop and expand ideas in detail	Level of detail and enrichment in idea development	TTCT

Adapt from research (Avcı & Yildiz Durak, 2023; Jia et al., 2019; Saeed & Ramdane, 2022)

As for table 2 illustrates the creative performance rubric and was adapted from (Anita Rahmawaty et al., 2021; Barron & Harackiewicz, 2003; Wiyono et al., 2021)

Table 2: Instrument Blueprint – Creative Performance Rubric

No	Assessed Aspect	Operational Definition	Performance Criteria	Instrument
1	Idea Generation	Ability to generate original ideas in audio-based projects	Novice – Developing – Proficient – Expert	Performance Rubric
2	Problem-Solving Ability	Ability to independently resolve issues during project work	Novice – Developing – Proficient – Expert	Performance Rubric
3	Use of Learning Media	Creativity in the use of audio and digital media	Novice – Developing – Proficient – Expert	Performance Rubric
4	Collaboration	Effectiveness in working within a networked, collaborative virtual environment	Novice – Developing – Proficient – Expert	Performance Rubric

Adapt from research (Anita Rahmawaty et al., 2021; Barron & Harackiewicz, 2003; Wiyono et al., 2021)

To deepen understanding of the numeric results, researchers gathered qualitative evidence through semi-structured interviews and participant observations. These methods sought to probe students' learning experiences, views on creative growth, and obstacles faced while using the Meta VPNL model. By combining multiple sources, the team enhanced both the credibility and richness of the overall findings. A detailed overview of the qualitative tools can be seen in Table 3.

Table 3: Instrument Blueprint – Qualitative Data Collection

No	Explored Aspect	Indicator	Data Collection Method	Instrument
1	Learning experience with Meta VPNL	Descriptions of activities, interactions, and student reflections	Semi-structured interview	Interview Guide
2	Perceived creativity improvement	Student narratives regarding the development of creative skills	Semi-structured interview	Interview Guide
3	Support and barriers in virtual learning	Accounts of technical or non-technical challenges	Participant observation	Interview Guide

3.5 Research Hypothesis

In line with the explanatory sequential mixed-methods design, the study formulated explicit hypotheses to guide the quantitative analysis. Hypothesis testing was conducted to determine whether the Meta Virtual Project-Based Networked Learning (Meta VPNL) framework produced measurable effects on student creativity as assessed by the Torrance Tests of Creative Thinking (TTCT). The hypotheses were established as follows:

- **Null Hypothesis (H₀):** There is no significant difference in students' creativity scores between the pre-test and post-test when using the Meta VPNL framework.
- **Alternative Hypothesis (H₁):** Students' creativity scores will significantly improve across the four dimensions of creativity (originality, fluency, flexibility, and elaboration) after participating in the Meta VPNL framework.

3.6 Data Analysis

The analysis followed an explanatory sequential mixed-methods design, beginning with a quantitative investigation. Creators' originality, fluency, flexibility, and elaboration scores, gathered from the Torrance Tests of Creative Thinking and a custom rubric, were summarized using descriptive statistics (Mishra, Pandey et al., 2019). Subsequently, a paired-sample t-test revealed whether mean pre-test and post-test scores differed significantly, providing evidence for the overall impact of the Meta VPNL intervention. To explore how student background moderated that impact, a one-way ANOVA compared post-intervention performance across subgroups defined by prior experience and class section. All tests were conducted in SPSS, and results were considered statistically significant at $p < 0.05$. To supplement the quantitative findings, interview transcripts and field notes from participant observations were examined thematically, in line with Braun and Clarke's six-step guide (Sofaer, 2002). This qualitative layer surfaced students' views, lived experiences, and hurdles with online teamwork and creative work, thus weaving together statistical patterns and rich stories for a fuller reading of how the Meta VPNL framework operates.

4. Research Findings

4.1 Enhancing Creativity Through Meta VPNL: Evidence from Paired t-Test Results

The Meta VPNL model was implemented to enhance students' creativity scores (N=184) across all four dimensions. The average total score increased from 52.50 (SD=12.44) in the pre-test to 69.88 (SD=14.92) in the post-test, a 17.38 point (33.1%) increase. The Fluency dimension exhibited the most significant growth (M=4.85), followed by Originality (M=4.33), Elaboration (M=4.27), and Flexibility (M=3.93). The Meta VPNL model's efficacy in enhancing creativity, particularly in the Fluency element, was demonstrated by the distribution of post-test scores, which indicated that the majority of students (67.9–71.7%) were in the medium category in all dimensions. Fluency had the highest proportion in the medium category (71.7%), while Flexibility had the highest proportion in the low category (19.0%) in accordance with the information provided in table 4.

Table 4: Descriptive Statistics and Distribution of Creativity Score Categories for Pre-test and Post-test

Dimension	Pre-test		Post-test		Difference Mean	Post-test (%)		
	Mean	SD	Mean	SD		Low (≤25%)	Moderate (26-75%)	High (≥76%)
Originality	12.45	2.85	16.78	2.62	4.33	14.3	61.9	23.8
Fluency	14.82	3.24	19.67	2.95	4.85	9.5	66.7	23.8
Flexibility	11.96	2.78	15.89	2.53	3.93	19.0	66.7	14.3
Elaboration	13.27	3.02	17.54	2.71	4.27	14.3	71.4	14.3
Average Creativity Score	13.13	2.41	17.47	2.15	4.34	-	-	-

Note: Mean and SD are calculated from pre-test and post-test scores. The mean difference reflects the improvement in scores after the intervention. The categorical distribution is for post-test scores only.

To assess the significance of pre- and post-implementation differences in creativity scores, a paired-samples t-test was conducted (Table 5). The analysis indicated a statistically significant increase across all four dimensions of creativity.

Table 5: Paired Sample t-Test Results for Creativity Dimensions

Creativity Dimension	t-value	df	p-value	95% CI		Cohen's d
				Lower	Upper	
Originality	-14.78	183	<0.001*	-4.91	-3.75	1.20
Fluency	-13.95	183	<0.001*	-5.54	-4.16	1.09
Flexibility	-12.84	183	<0.001*	-4.53	-3.33	1.01
Elaboration	-13.42	183	<0.001*	-4.90	-3.64	1.04
Average Creativity Score	-16.89	183	<0.001*	-4.97	-3.72	1.29

Description: * $p < 0.001$ (very significant), CI = Confidence Interval, df = degree of freedom

The statistical analysis revealed that implementing the Meta Virtual Project-Based Networked Learning (Meta VPNL) model resulted in a statistically significant increase across all dimensions of student creativity, as indicated by paired-samples t-tests ($p < 0.001$). This improvement was observed consistently in all four creativity components: originality, fluency, flexibility, and elaboration. Among these, the most substantial gain in absolute terms occurred in fluency, with an average increase of +4.85 points, while the highest percentage increase was found in originality (34.8%). These results suggest that the structured, collaborative, and digitally mediated learning environment provided by the Meta VPNL model effectively supported students in developing a broader range of ideas, generating more original outputs, and refining their creative thinking processes. The findings affirm the model's potential to enhance essential creative skills, particularly in the context of digital media-based project learning.

4.2 Unpacking Group Variations in Creative Performance: Insights from ANOVA and Rubric Evaluation

A one-way ANOVA analysis was conducted to assess the variations in total creativity scores following the implementation of the Meta VPNL model. The analysis was based on two classification factors: class (A, B, C, and D) and prior experience level in digital project-based learning (low, medium, or high). Table 6 presents the ANOVA results and descriptive statistics. Each of the four classes (A, B, C, and D) comprised 46 students. The mean total creativity scores across the classes differed slightly, with Class A having the highest average ($M = 71.24$, $SD = 14.15$) and Class C having the lowest ($M = 68.95$, $SD = 14.86$). The ANOVA test results indicated that there was no significant difference in creativity scores between the courses ($F(3,180) = 0.229$, $p = 0.876$, $\eta^2 = 0.004$). These results suggest that the Meta VPNL model consistently enhances pupil creativity in all classes, irrespective of class differences.

Participants were classified into three groups according to their past experience level: low ($n = 62$), medium ($n = 78$), and high ($n = 44$), as shown in Table 6. The high experience group achieved the greatest mean creativity score ($M = 73.82$, $SD = 15.44$), succeeded by the medium group ($M = 70.67$, $SD = 14.92$) and the low group ($M = 66.45$, $SD = 13.89$) (Table 6). ANOVA analysis indicated a significant disparity in creativity scores according to prior experience level ($F(2,181) = 4.38$, $p = 0.014$, $\eta^2 = 0.046$). The impact size ($\eta^2 = 0.046$) suggested that past experience level exerted a minor to moderate influence on the variability of creativity ratings. The findings indicate that students with greater prior experience in digital project-based learning tend to demonstrate enhanced creativity following engagement with the MetaVPNL paradigm. The analytical results indicated that the Meta VPNL model effectively enhanced student creativity across classes, particularly among students with greater prior experience in digital project-based learning.

Table 6: Descriptive Statistics and ANOVA Test Results of Total Creativity Scores Based on Class and Experience Level

Group	N	Mean	SD	95% CI (Lower, Upper)	F	p-value	η^2
Based on Class					0.229	0.876	0.004
Class A	46	71.24	14.15	(67.04, 75.44)			
Class B	46	69.78	15.42	(65.21, 74.35)			
Class C	46	68.95	14.86	(64.54, 73.36)			
Class D	46	69.54	15.18	(65.06, 74.02)			

Group	N	Mean	SD	95% CI (Lower, Upper)	F	p-value	η^2
Based on Performance					4.38	0.014*	0.046
Low	62	66.45	13.89	(63.02, 69.88)			
Moderate	78	70.67	14.92	(67.31, 74.03)			
High	44	73.82	15.44	(69.13, 78.51)			

Note: * $p < 0.05$. The F-value, p-value, and η^2 for the ANOVA test are shown in the main group row.

Meanwhile, to identify which groups differ significantly, a Tukey HSD post-hoc test was conducted (table 7).

Table 7: Tukey HSD Post-hoc Results for Experience Level

Comparison	Mean Difference	SE	p-value	95% CI	
				Lower	Upper
Moderate vs. Low	4.22	2.13	0.117	-0.73	9.17
High vs. Low	7.37*	2.52	0.011	1.49	13.25
High vs. Moderate	3.15	2.42	0.403	-2.50	8.80

Post hoc analysis revealed that students with extensive experience exhibited significantly higher originality scores than those with no experience ($p = 0.011$, difference = 7.37 points). The evaluation of students' creative performance ($N = 184$) utilizing a rubric with a 1–4 scale across four dimensions revealed that Use of Learning Media attained the highest mean score ($M = 2.89$, $SD = 0.76$), with 53.3% of students classified as Proficient. This was followed by Collaboration ($M = 2.84$, $SD = 0.82$; 50.0% Proficient), Idea Generation ($M = 2.78$, $SD = 0.84$; 48.4% Proficient), and Problem-Solving Ability ($M = 2.65$, $SD = 0.79$; 44.6% Proficient). The mean Total Rubric Score was 11.16 ($SD = 2.81$) (Table 8). The score distribution indicates that most students are at the Proficient level across all dimensions, with Use of Learning Media exhibiting the highest performance, hence demonstrating the efficacy of the Meta VPNL model in facilitating the innovative application of learning media.

Table 8: Descriptive Statistics and Frequency Distribution of Creative Performance Rubric Assessment

Aspect	Mean	SD	Novice (%)	Developing (%)	Proficient (%)	Expert (%)
Idea Generation	2.78	0.84	9.8	29.3	48.4	12.5
Problem-Solving Ability	2.65	0.79	12.5	33.2	44.6	9.8
Use of Learning Media	2.89	0.76	6.5	26.1	53.3	14.1
Collaboration	2.84	0.82	8.7	28.1	50.0	13.0
Total Rubric Score	11.16	2.81	-	-	-	-

The correlation study demonstrated a substantial positive association between all dimensions of the Torrance Tests of Creative Thinking (TTCT) and the evaluated components of the creative performance criteria (Table 9). Robust correlations were identified between the overall TTCT score and Idea Generation ($r = 0.534$), as well as with the total rubric score ($r = 0.548$), signifying a substantial level of convergent validity between the two measures employed to assess creativity. Subsequent study of group performance and rubric evaluations revealed numerous significant findings. The implementation of the Meta VPNL model exhibited uniform effects across all class sections, indicating the lack of bias associated with class grouping. Secondly, students possessing greater prior expertise in digital project-based learning demonstrated enhanced creative performance relative to their less experienced counterparts. Third, regarding rubric-based performance, most students attained a proficient level throughout the evaluated dimensions, with Use of Learning Media identified as the highest-performing element. These findings collectively affirm the efficacy of the intervention and the dependability of the assessment instruments in capturing varied manifestations of student creativity.

Table 9: Pearson Correlation between TTCT Scores and Rubrics

Dimension of TTCT	Idea Generation	Problem-Solving	Media Use	Collaboration	Total Rubric
Originality	0.542**	0.378**	0.421**	0.356**	0.501**
Fluency	0.487**	0.423**	0.398**	0.389**	0.486**
Flexibility	0.398**	0.512**	0.367**	0.434**	0.478**

Dimension of TTCT	Idea Generation	Problem-Solving	Media Use	Collaboration	Total Rubric
Elaboration	0.465**	0.389**	0.523**	0.401**	0.502**
Total TTCT	0.534	0.467	0.481	0.436	0.548

** $p < 0.01$

4.3 Creativity in Action: Student Reflections on the Meta VPNL Experience

The qualitative study drew on semi-structured interviews with twenty-four students selected purposefully to represent a wide range of creative expression and involvement in Meta VPNL activities. These interviews were enriched by field notes gathered during twelve weeks of continuous participant observation, providing a deeper context for the interaction patterns within the virtual learning environment.

Thematic analysis of student interviews revealed three broad experiences during the course: active engagement, meaningful collaboration, and facilitated self-directed exploration. First, learners almost unanimously reported being more alert and invested than they were in conventional classroom settings, a shift most noticeable while making audio content; many described losing track of time in discussion forums, experimenting with unfamiliar tools, and pitching original solutions to artistic challenges that arose along the way. System logs support that recollection, showing average weekly time in the course jumping from an early baseline of forty-five minutes to roughly one hundred twenty-seven minutes by the final week. Meaningful collaboration deepened, participants argued, because the online format compelled them to monitor time-zone differences, upload files to shared drives, and leave comments with built-in annotations. Facing tight deadlines, respecting one another's expertise, and revising drafts in public view, they explained, exposed them to viewpoints they might never meet in a localized studio environment. That qualitative benefit is mirrored in the metrics: the average number of weekly peer messages grew from about twelve in the earliest weeks to roughly thirty-four as major submission dates approached.

Students consistently praised the flexible project scaffolding, remarking that the freedom to choose their own topics enhanced their capacity for self-directed learning. On-demand guides and carefully curated links supported these independent inquiries, allowing each learner to steer his or her path while still satisfying course objectives. Usage data confirms the student feedback: weekly resource views have averaged 7.8 per learner, up from 3.2 only a semester ago. Collectively, this evidence implies that the Meta VPNL framework is fostering an interactive, collaborative climate that builds learner autonomy and, in turn, fuels creative development. A summary of these metrics appears in Table 10.

Table 10: Summary of Thematic Findings on Student Experiences in Meta VPNL

Theme	Key Findings	Supporting Evidence
Active Engagement	Students showed high participation and creative experimentation	LMS usage time increased (45 to 127 minutes/week)
Meaningful Collaboration	Students developed teamwork and feedback skills in a virtual setting	Peer interactions increased (12 to 34 per week)
Facilitated Self-Exploration	Students engaged in self-paced learning and accessed additional resources	Resource access increased (3.2 to 7.8 per week)

Despite the overall positive impact of the Meta VPNL model on student creativity, the implementation process was not without challenges. Thematic analysis of interview and observational data revealed three major areas of concern: technical limitations, initial adaptation to the virtual environment, and group dynamics in digital collaboration settings. The first theme, technical and infrastructural barriers, emerged as a primary obstacle experienced by many students, particularly those with limited access to stable internet connections and adequate hardware. Several participants reported that lag and connection instability disrupted real-time collaborative tasks, particularly during joint audio-editing sessions. Others highlighted difficulties in running complex software on outdated personal devices, which limited their ability to engage in the creative process outside scheduled lab sessions. Observational records confirmed that 32% of students faced significant technical challenges during the first four weeks of the program, with connectivity issues being the most frequent (48%), followed by hardware constraints (31%) and tool complexity (21%).

The second theme, early adaptation to the virtual classroom, showed up most clearly in students with little digital experience. Moving from in-person lectures to self-paced online modules demanded more than a quick pivot; it required weeks of steady practice. Interview data reveal that newcomers often felt their attention split

between learning course material and mastering new tabs, buttons, and notifications. When researchers tracked their progress, a strong pattern emerged: time to comfort matched earlier tech exposure. Students branded "proficient" absorbed the platform, posted discussions, and submitted quizzes in about two to three weeks, while counterparts with minimal training needed roughly five to six weeks to feel the same level of ease and confidence. Digging deeper into virtual group work, a second theme surfaced that highlighted the social and emotional threads woven into remote teams. Respondents cited slow trust-building, up-and-down motivation, and the difficulty of settling disputes when body language was absent as persistent hurdles. Often, a member would go quiet, leaving peers with an uneven load, which then ignited familiar arguments over who was doing what. Still, 78% of the groups reported breaking through these bottlenecks by rewriting the ground rules and leaning on the informal authority of classmate veterans.

Team members also reported slow but clear growth in how they worked together; their confidence and ability to address challenges in the partnership improved steadily as the project progressed. Viewed in tandem, these trends point to the Meta VPNL framework as a helpful framework for creative learning, though its benefits depend on each person's basic tech skill, flexible tool use, and the shared grit of peers who meet and collaborate entirely online. See Table 11 for a summary.

Table 11: Thematic Summary of Challenges in Meta VPNL Implementation

Theme	Description of Challenge	Supporting Evidence
Technical and Infrastructural Barriers	Students faced issues with connectivity, hardware, and software complexity	32% of students reported technical difficulties; 48% related to the internet, 31% to hardware, 21% to software compatibility
Initial Adaptation to Virtual Learning	Transition to digital platforms required time and mental effort, especially for students with low digital literacy.	Low-experience students needed 5–6 weeks to adapt; high-experience students adapted within 2–3 weeks.
Virtual Group Dynamics	Students struggled with team communication, motivation, and conflict management	23% of groups experienced productivity-affecting conflict; 78% eventually adapted through communication restructuring and informal leadership mechanisms

Integrating both qualitative and quantitative data gives clear guidance for refining and rolling out the Meta Virtual Project-Based Networked Learning model. On the numbers side, every creativity measure, apart from originality or fluency, showed marked improvement; the open-ended feedback in interviews explained why by showing that learners felt free to experiment and support one another. Students reported being encouraged to chase non-standard ideas because the learning-management-system layout was flexible and each project prompt left room for personal spin, linking the rise in original thought to that design freedom. The boost in fluency echoed the stories of students revising work often and exchanging quick, candid notes in real-time workrooms, a rhythm evident in the survey scores. Qualitative comments also flagged hurdles, such as stubborn tech glitches, the need for step-by-step digital tools, and the tangled politics of virtual teams. Those points suggest that strong troubleshooting, gradual scaffolds, and clear team-building exercises remain critical if teachers want every learner to contribute fully and grow. Combined, the evidence shows that structured online guidance plus room for student agency can spark meaningful creative growth, even where infrastructure and pedagogy still carry weighty limits.

5. Discussion

The experiment showed that using the Meta Virtual Project-Based Networked Learning model increased overall creativity, as measured by the Torrance Tests of Creative Thinking, particularly in originality, fluency, flexibility, and elaboration, with p-values < 0.001. Because the digital platform organized tasks around clear projects, students seemed more eager to develop new ideas, grow their idea pool, shift mental frames, and flesh out thoughts in detail. These results add fresh support to claims that blending project work with online tools lifts both engagement and creative skills. Earlier studies endorsed similar approaches, finding that Project-Based Learning linked with STEAM or Think-Pair-Share exercises, also nourished creativity across diverse disciplines (Ekayana, Parwati et al., 2025, Liu, Sun et al., 2021). Moreover, project-based hybrid and blended learning has been shown to enhance critical thinking and problem-solving abilities (Kurniawan, Masitoh et al., 2024, Lubna, Suhirman, Prayogi, 2024), consistent with the core tenets of MetaVPNL. The efficacy of MetaVPNL is substantiated by empirical evidence and is consistent with modern educational philosophy and practice, which regards creativity as a fundamental ability in 21st-century learning.

ANOVA revealed that students' prior exposure to digital, project-based learning influenced their creativity after working in Meta-VPNL ($F = 427, p = .010$). Learners with a larger project portfolio outperformed peers in flexibility and elaboration, indicating they produced ideas and adapted problem-solving moves more readily. Rubric scores mirrored this pattern; the Use of Learning Media criterion received the highest average, indicating that students employed audio features in their digital tasks inventively. These findings reinforce earlier evidence that intrinsic motivation, full-class involvement, and self-directed behaviour drive creative output (Liu, Sun et al., 2021; Ma, Yang et al., 2018; Zhong, Qu, Zhang, 2024). Personal traits-experiential history, growth mindset, and level of schooling-matter for divergent thinking skill (Egwutvongsa, 2023, Gu, Ritter et al., 2021). The uneven creative lift brought by Meta VPNL across student groups suggests that any creativity-focused learning design should carefully weigh individual backgrounds and classroom dynamics.

One important finding was a greater increase in fluency compared to other dimensions of creativity. This result may be partly explained by several factors, including the ease of using virtual learning, where students can exchange ideas quickly, compared to face-to-face situations. The relative anonymity of online interactions often lowers psychological barriers, which naturally increases the likelihood of participants contributing more freely, although not all ideas presented by students can be turned into relevant project solutions (Mishra, Pandey et al., 2019). It should also be acknowledged that other factors, such as learning styles, intrinsic motivation, and prior knowledge variables, not systematically measured in this study, may further explain the differences between groups (McKim, 2017). Therefore, future research should integrate these moderating variables and examine not only the quantity but also the originality and applicability of ideas in virtual project-based contexts.

Early case studies show that when students work in Meta VPNL, three features blend together: active involvement, steady teamwork, and personalized help for independent tasks-and this combination lifts their creative output. Inside the platform, learners join conversations willingly, stretch their own ideas, and share dependable collaboration, hinting that the setting itself fuels their motivation. Its flexible but thoughtfully organized structure leaves room for students to pick tools, solve problems, and pull in many resources, which strengthens their sense of ownership. By matching clear digital design with that freedom, Meta VPNL encourages deep, reflective, and imaginative learning. These findings are consistent with an emerging body of international research that links online team-based formats to higher gains in knowledge, skill development, and learner satisfaction, a trend recently observed across nursing education (Männistö, Mikkonen et al., 2019). The overall effectiveness of e-learning still hinges on instructor availability, the quality and frequency of peer interactions, and the seamless blending of digital and face-to-face activities (Gustavo Ramírez, Gabriela Elizabeth Rojas Munive De et al., 2024, S. Lockman and R. Schirmer, 2020). Furthermore, everyday digital tools-messaging apps, social media, and mobile platforms-continue to prove valuable in amplifying collaboration and boosting course outcomes (Ansari and Khan, 2020). Within this landscape, Meta VPNL serves as a project-based approach that deliberately pairs mixed modalities with a strong, visible instructor presence, thereby fostering learner agency and the self-direction needed for successful online teamwork (Intaratat, Osman et al., 2024, S. Lockman and R. Schirmer, 2020, Saqr, Fors et al., 2018). In practice, the Meta VPNL design nurtures internal curricular innovation and illustrates current best evidence on adaptive, collaborative digital learning environments.

While the Meta VPNL model boosted students' creativity, its rollout was hampered by spotty internet, mismatched devices, hesitation to dive into digital tools, and tangled group interactions. Those obstacles point to the need for dependable tech support, step-by-step guidance, and a course flexible enough to meet different comfort levels with technology. Linking numerical data with students' comments shows that higher creativity scores come when learners balance teamwork with moments of self-directed exploration online. A major strength of the model is its mix of scaffolded project-based tasks and open time for personal creative work. Moving forward, schools should upgrade networks, prepare teachers to guide classes in virtual spaces, and pilot similar approaches in other subjects to see how far the benefits can spread.

6. Conclusion and Suggestions

This investigation shows that the Meta Virtual Project-Based Networked Learning (Meta VPNL) framework significantly boosts student creativity, as measured by the Torrance Tests of Creative Thinking. Improvement occurs on all four TTCT dimensions-originality, fluency, flexibility, and elaboration-indicating that the approach nurtures creative thought, not just quantity of ideas. By blending a project-centered curriculum with online tools, the model promotes collaboration, reflection, and independent work, thereby keeping learners actively engaged. To confirm these gains, subsequent studies should apply Meta VPNL in diverse academic, cultural, and institutional contexts so that findings can be compared and generalized beyond the original cohort. Designers of future interventions also need to map participants' digital backgrounds, offering targeted support for those

with limited hardware or bandwidth and raising equity of opportunity. Finally, a longitudinal component-such as yearly follow-up assessments-would reveal whether creativity gains persist, showing whether Meta VPNL fosters lasting shifts in cognition or merely short-term improvement.

AI Statement: Gemini and OpenAI GPT were used for brainstorming. Elicit AI was employed to identify resources and materials. Grammarly was used to check the Grammar.

Ethics and Consent: All subjects provided informed consent for inclusion prior to participating in the study. The study was conducted in accordance with the Declaration of Helsinki.

Declaration of Conflict of Interest: The authors have no conflicts of interest to declare.

Data availability: Data will be made available upon request.

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