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Research Article

Beyond Divergent Thinking: A Longitudinal Study of Creativity Development Trajectories in Adolescents Across Formal and Informal Learning Environments

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Abstract
Creativity has become a fundamental competency for adolescents navigating increasingly complex educational, technological, and social environments. Conventional research has predominantly conceptualized creativity through divergent thinking, providing limited understanding of how creativity develops over time across multiple learning contexts. This study aimed to examine longitudinal creativity development trajectories among adolescents by investigating the interactions among formal schooling, informal learning experiences, creative self-efficacy, intrinsic motivation, creative identity, and collaborative engagement. A mixed-methods longitudinal sequential explanatory research design was employed involving 720 secondary school students observed across four measurement waves over three years. Quantitative data were collected using standardized creativity, motivation, self-regulated learning, and creative identity instruments, complemented by academic records, extracurricular participation logs, and digital portfolio analytics. Qualitative evidence was obtained through semi-structured interviews, focus group discussions, classroom observations, family interviews, reflective journals, and portfolio analysis. Findings revealed significant longitudinal improvements in creative thinking, creative self-efficacy, intrinsic motivation, self-regulated learning, collaborative competence, creative identity, and academic achievement.

Keywords: Adolescent Development, Creativity Development, Educational Psychology

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INTRODUCTION

Contemporary societies increasingly recognize creativity as a fundamental competency for addressing complex social, technological, economic, and environmental challenges. Educational systems worldwide are expected to cultivate learners who can generate innovative ideas, solve ill-structured problems, adapt to rapidly changing contexts, and collaborate effectively across disciplinary boundaries (Cho, 2024; Eymann, 2022; Rominger, 2022). Creativity has consequently become a central educational objective alongside critical thinking, communication, collaboration, and digital literacy within twenty-first century learning frameworks. Despite widespread recognition of its importance, creativity remains one of the most difficult human competencies to conceptualize, assess, and systematically develop because it emerges through dynamic interactions among cognitive, motivational, emotional, social, and environmental factors.

Traditional creativity research has frequently emphasized divergent thinking as the principal indicator of creative ability. Measures of fluency, flexibility, originality, and elaboration have contributed significantly to understanding creative cognition, yet they provide only a partial representation of how creativity develops across adolescence (Byrge, 2025; Sarantou, 2025; Schlimbach, 2024). Contemporary perspectives increasingly describe creativity as a developmental process involving domain knowledge, identity formation, self-regulation, intrinsic motivation, emotional resilience, collaborative participation, and environmental support. Such multidimensional perspectives suggest that creativity cannot be adequately understood through isolated cognitive assessments but requires investigation across authentic learning experiences occurring within diverse educational settings.

Adolescence represents a particularly significant developmental period because substantial cognitive, emotional, social, and neurological changes occur simultaneously with expanding educational opportunities (Khan, 2025; Mazza, 2023; Patterson, 2024). Formal learning environments, including schools and structured academic programs, interact continuously with informal learning experiences such as family activities, community engagement, extracurricular participation, digital media use, maker spaces, artistic practice, and peer collaboration. These interconnected learning contexts collectively influence how adolescents develop creative confidence, creative identity, and innovative problem-solving abilities over time. Comprehensive longitudinal investigation is therefore necessary to understand creativity as a developmental trajectory rather than a static individual characteristic measured at a single point in time.

Educational institutions continue to prioritize creativity as a desired learning outcome; however, instructional practice frequently relies upon fragmented approaches emphasizing isolated classroom activities or short-term interventions (Demel, 2024; Kunzel, 2025; Yaden, 2023). Creativity is often treated as an independent cognitive skill detached from motivational development, emotional engagement, identity formation, and authentic learning experiences occurring beyond formal educational settings. Such instructional fragmentation limits opportunities to understand how creativity develops naturally across multiple learning environments throughout adolescence.

Existing educational assessment practices also present important limitations because creativity is commonly evaluated using divergent thinking tests administered during relatively brief instructional periods (Koutstaal, 2025; Organisciak, 2023; Wickramasinghe, 2023). These assessments provide valuable information regarding immediate cognitive performance but offer comparatively limited understanding of developmental change, contextual influences, learner variability, or interactions among formal and informal educational experiences. Relationships among creativity, self-regulated learning, intrinsic motivation, collaborative participation, digital engagement, and creative identity therefore remain insufficiently understood across longitudinal developmental trajectories.

Research concerning creativity development frequently investigates school-based learning independently from extracurricular activities, family influence, community participation, and digitally mediated learning experiences (Barsch, 2025; Sordia, 2022; Tsakalerou, 2025). Adolescents continuously move across multiple educational contexts where different opportunities, expectations, resources, and social relationships influence creative development. Limited integration of these interconnected environments restricts theoretical understanding of creativity as a dynamic developmental phenomenon emerging through continuous interaction between individuals and their educational ecosystems.

This study aims to investigate longitudinal trajectories of creativity development among adolescents across formal and informal learning environments (Chuang, 2025; Li, 2025; Sekar, 2025). Particular emphasis is placed on examining how creativity evolves through interactions among cognitive development, intrinsic motivation, creative self-efficacy, emotional engagement, collaborative participation, digital learning experiences, and educational opportunities over time. Achievement of these objectives is expected to strengthen theoretical understanding of creativity as a developmental process extending beyond divergent thinking alone.

Research also seeks to investigate relationships among school-based instruction, extracurricular participation, family learning environments, digital creativity, peer collaboration, self-regulated learning, and creative identity formation. Comparative analysis across multiple educational contexts will identify environmental factors that most effectively support sustained creativity development during adolescence (Abell, 2024; Foulds, 2024; Winslow, 2022). Such investigation aims to clarify how educational ecosystems contribute collectively to long-term creative growth rather than producing isolated instructional outcomes.

Broader objectives include advancing interdisciplinary understanding of creativity by integrating developmental psychology, educational psychology, learning sciences, creativity research, neuroscience, curriculum studies, and informal learning into a unified conceptual framework. Findings are expected to contribute to evidence-based educational policies supporting creativity development while providing practical guidance for teachers, school leaders, families, community organizations, and educational policymakers.

Existing literature has extensively examined creativity, divergent thinking, creative cognition, educational innovation, and creative pedagogy across various educational contexts. Numerous investigations report positive effects of inquiry-based learning, project-based learning, collaborative learning, arts education, and technology integration on creativity outcomes. Comparatively limited research investigates longitudinal creativity trajectories by simultaneously integrating formal schooling, informal learning environments, motivational development, identity formation, emotional engagement, and learner agency within a comprehensive developmental framework. Such fragmentation limits understanding of creativity as a dynamic developmental process unfolding across adolescence.

Current investigations frequently evaluate creativity using cross-sectional research designs and standardized divergent thinking assessments. Comprehensive longitudinal examination of creativity encompassing cognitive flexibility, creative self-efficacy, intrinsic motivation, collaborative participation, emotional resilience, digital creativity, and authentic creative production remains comparatively underdeveloped. Existing analytical approaches therefore provide only partial explanations regarding how creativity develops continuously through interactions among diverse educational experiences.

Available studies also tend to emphasize classroom instruction while giving comparatively limited attention to family influence, community participation, extracurricular learning, online creative communities, maker spaces, cultural engagement, and digital media environments. Evidence concerning how these educational ecosystems collectively shape adolescent creativity remains limited. This study addresses these gaps by proposing an

integrated developmental framework connecting formal education, informal learning, psychological development, and longitudinal creativity trajectories.

Novel contribution of this study lies in proposing a developmental framework that conceptualizes creativity as a multidimensional longitudinal process extending beyond traditional divergent thinking paradigms. The proposed framework integrates cognitive development, creative identity, intrinsic motivation, self-regulated learning, emotional engagement, collaborative participation, formal schooling, informal learning environments, and digital creativity into a unified explanatory model. This multidimensional perspective expands creativity research beyond isolated cognitive assessment by emphasizing continuous developmental interaction among educational, psychological, and environmental factors.

Scientific significance further resides in advancing interdisciplinary integration among developmental psychology, educational psychology, creativity research, learning sciences, neuroscience, curriculum studies, sociology of education, and informal learning. Creativity is interpreted as the outcome of coordinated interaction among learner characteristics, educational experiences, motivational processes, social relationships, cultural participation, and digital learning opportunities rather than as a fixed cognitive ability. Such conceptual integration contributes to broader theoretical discussions concerning adolescent development, lifelong creativity, learner agency, and educational innovation within rapidly changing knowledge societies.

Practical justification emerges from increasing international emphasis on creativity as a fundamental competency for future education, workforce development, entrepreneurship, scientific innovation, and social problem-solving. Teachers, curriculum developers, school leaders, families, community organizations, and policymakers require evidence-based guidance regarding how creativity develops across multiple educational environments throughout adolescence. Successful implementation of the proposed framework has the potential to improve curriculum design, instructional practice, family engagement, extracurricular programming, digital learning environments, and educational policy while supporting sustainable creativity development beyond conventional classroom boundaries.

RESEARCH METHOD

Research Design

This study employed a mixed-methods longitudinal sequential explanatory research design to investigate creativity development trajectories among adolescents across formal and creativity-related constructs with qualitative exploration of adolescents' developmental experiences, educational participation, and contextual influences over a three-year period. This design was selected because creativity represents a dynamic developmental process shaped by continuous interaction among cognitive, motivational, emotional, social, and environmental factors. Longitudinal measurement enabled identification of developmental trajectories, whereas qualitative evidence provided deeper explanations regarding the mechanisms through which formal and informal learning environments contributed to creativity development.

The quantitative component adopted a prospective longitudinal cohort design involving four waves of data collection conducted at twelve-month intervals. Participants completed standardized assessments measuring creative thinking, creative self-efficacy, intrinsic motivation, self-regulated learning, collaborative competence, emotional engagement, creative identity, and academic achievement. Growth trajectories were examined to identify developmental patterns across adolescence while comparing learners with different levels of participation in formal education, extracurricular activities, digital creative communities, family learning experiences, and community-based educational programs. This approach enabled evaluation of both developmental change and contextual variation over time.This study uses a qualitative approach …

Research Target/Subject

The qualitative component followed each quantitative phase to provide comprehensive understanding of adolescents' lived experiences during creativity development. Semi-structured interviews, focus group discussions, reflective journals, classroom observations, extracurricular activity observations, family interviews, and portfolio analyses were conducted with adolescents, teachers, parents, community mentors, and extracurricular instructors. Qualitative investigation explored learner identity formation, motivational development, emotional experiences, collaborative participation, creative problem-solving, educational opportunities, and perceived environmental support. Integration of quantitative and qualitative findings enabled holistic interpretation of creativity as a developmental phenomenon extending across multiple educational contexts.

Research Procedure

The study population consisted of adolescents enrolled in lower and upper secondary schools located in urban, suburban, and rural educational settings. Participants represented diverse socioeconomic backgrounds, academic achievement levels, cultural communities, family structures, and patterns of participation in extracurricular activities, arts education, sports, digital creative platforms, community organizations, and informal learning experiences. Teachers, parents, extracurricular mentors, school counselors, and community educators also participated to provide complementary perspectives regarding adolescents' creativity development throughout the study period.

The quantitative sample comprised 720 adolescents selected through stratified random sampling from twelve secondary schools. Participants entered the study during the first year of secondary education and remained under observation throughout the three-year longitudinal investigation. Stratification ensured balanced representation according to gender, socioeconomic status, geographical location, academic achievement, and participation in formal and informal learning activities. Attrition management procedures maintained an overall participant retention rate exceeding 90% across all measurement waves. The qualitative sample consisted of 48 purposively selected participants, including 24 adolescents, 8 teachers, 8 parents, and 8 extracurricular mentors recognized for their sustained participation and diverse educational experiences throughout the research period.

Instruments, and Data Collection Techniques

Units of analysis included individual-level, educational-level, and contextual-level variables. Individual variables comprised creative thinking, creative self-efficacy, intrinsic motivation, emotional engagement, self-regulated learning, creative identity, collaborative competence, resilience, and academic achievement (Berkel, 2023; Fusi, 2024; Marzi, 2025). Educational variables included instructional design, teacher support, assessment practices, extracurricular participation, project-based learning, and digital creativity activities. Contextual variables encompassed family learning environments, community engagement, peer collaboration, cultural participation, digital media use, maker activities, and institutional support for creativity development.

Data Analysis Technique

Quantitative data were collected using internationally validated instruments adapted for adolescent creativity research. Creative thinking was assessed using standardized divergent and convergent thinking measures together with authentic creative performance assessments. Creative self-efficacy was measured using the Creative Self-Efficacy Scale, intrinsic motivation through the Academic Motivation Scale, self-regulated learning using the Motivated Strategies for Learning Questionnaire, emotional engagement through the Student Engagement Scale, and creative identity using the Creative Identity Inventory. Academic

achievement records, extracurricular participation logs, digital learning analytics, and portfolio assessments complemented standardized questionnaires to provide objective indicators of creativity-related development across multiple learning environments.

Qualitative evidence was obtained through semi-structured interview protocols, focus group discussions, learner reflective journals, classroom observation checklists, extracurricular activity observations, family interviews, digital portfolio analysis, and document review. Interview questions explored adolescents' perceptions of creativity, motivational experiences, educational opportunities, collaborative interaction, emotional challenges, digital creativity, family support, and community participation. Creative portfolios containing written work, artistic productions, multimedia projects, innovation challenges, and collaborative assignments were analyzed to identify longitudinal patterns of creative development. School curriculum documents, extracurricular program records, community learning documentation, and teacher evaluation reports provided additional contextual evidence supporting qualitative interpretation.

Instrument validity was established through expert review involving specialists in educational psychology, developmental psychology, creativity research, learning sciences, curriculum studies, and psychometrics. Construct validity was evaluated using Confirmatory Factor Analysis, while internal consistency reliability was assessed through Cronbach's alpha coefficients exceeding 0.80 across all principal constructs. Longitudinal measurement invariance testing confirmed consistency of measurement across successive data collection waves. Qualitative trustworthiness was strengthened through methodological triangulation, member checking, peer debriefing, prolonged engagement, intercoder agreement, and comparison across multiple documentary sources. Integration of quantitative and qualitative evidence enhanced the credibility, dependability, transferability, and confirmability of the research findings.

RESULTS AND DISCUSSION

Quantitative analysis included 720 adolescents who participated in a three-year longitudinal study involving four waves of data collection across formal and informal learning environments. The cohort represented students from twelve secondary schools with diverse socioeconomic backgrounds, geographical regions, and levels of participation in extracurricular activities, family-based learning, community programs, and digital creative platforms. Primary variables included creative thinking, creative self-efficacy, intrinsic motivation, self-regulated learning, creative identity, emotional engagement, collaborative competence, and academic achievement. Secondary data were obtained from school academic records, extracurricular participation logs, digital portfolio analytics, creative competition records, community learning documentation, and teacher evaluation reports to provide comprehensive evidence of creativity development over time.

Table 1. Longitudinal Development of Creativity Across Formal and Informal Learning Environments

Development Indicator	Baseline (Year 1)	Final Measurement (Year 3)	Improvement
Creative Thinking (0–100)	72.64	**87.93**	+21.05%
Creative Self-Efficacy (1–5)	3.41	**4.62**	+35.48%

Intrinsic Motivation (1–5)	3.53	**4.68**	+32.58%
Self-Regulated Learning (0–100)	74.82	**89.51**	+19.63%
Creative Identity (1–5)	3.36	**4.57**	+36.01%
Collaborative Competence (1–5)	3.58	**4.69**	+31.01%
Academic Achievement (0–100)	78.21	**88.84**	+13.59%
Participation in Creative Activities (%)	63.70	**90.40**	+41.92%

Descriptive statistics indicate continuous improvement across all measured dimensions of creativity throughout the three-year observation period. The greatest increases occurred in participation in creative activities, creative identity, creative self-efficacy, and intrinsic motivation. School documentation and extracurricular participation records further revealed that adolescents who consistently engaged in artistic, scientific, technological, community-based, and digital creative activities demonstrated substantially stronger developmental trajectories than peers relying primarily on classroom learning experiences.

Observed improvements primarily resulted from sustained interaction between formal educational experiences and diverse informal learning opportunities. School-based project learning, inquiry-oriented instruction, collaborative problem-solving, and interdisciplinary learning encouraged the development of cognitive flexibility, while extracurricular activities, family engagement, digital creativity platforms, and community participation strengthened creative confidence, learner autonomy, and authentic creative expression. Creativity therefore developed through cumulative educational experiences rather than isolated instructional interventions.

Educational psychology indicators similarly demonstrated progressive growth in motivational and emotional dimensions supporting creativity development. Increasing creative self-efficacy enabled adolescents to approach complex challenges with greater confidence, while enhanced intrinsic motivation encouraged sustained participation in creative learning activities. Growth in creative identity further reflected adolescents' increasing perception of themselves as capable innovators, problem-solvers, and contributors within diverse educational and social environments.

Subgroup analysis demonstrated meaningful differences in creativity trajectories according to patterns of educational participation. Adolescents actively participating in extracurricular programs, arts education, science clubs, digital creative communities, maker spaces, and community service projects demonstrated significantly steeper creativity growth than peers with limited participation beyond formal classroom instruction. Comparable developmental patterns were observed across gender groups, although learners with sustained engagement in multiple learning environments consistently achieved the highest overall creativity scores.

Longitudinal portfolio analysis revealed continuous improvement in originality, complexity, interdisciplinary thinking, collaborative creativity, and reflective problem-solving throughout the observation period (Hoffmann, 2023; Missier, 2022; Vaisarova, 2024). Teacher evaluations documented greater learner initiative, increased willingness to experiment with novel ideas, stronger peer collaboration, and improved capacity to integrate knowledge across

academic disciplines. Family interviews similarly reported increasing independence, curiosity, persistence, and creative confidence among participating adolescents.

Inferential statistical analyses included repeated-measures analysis of variance (ANOVA), latent growth curve modeling, multilevel modeling, Structural Equation Modeling (SEM), growth mixture modeling, cross-lagged panel analysis, mediation analysis, moderation analysis, and effect size estimation. Preliminary assumption testing confirmed multivariate normality, longitudinal measurement invariance, and acceptable model fit across all measurement waves. Structural model evaluation demonstrated satisfactory goodness-of-fit indices ($\chi^2/df = 2.16$, CFI = 0.97, TLI = 0.96, RMSEA = 0.042). Statistical significance was determined using $\alpha = 0.05$.

Results demonstrated statistically significant longitudinal improvement across all principal constructs. Creative thinking increased significantly over time ($F = 86.74$, $p < 0.001$), creative self-efficacy demonstrated substantial growth ($F = 81.28$, $p < 0.001$), intrinsic motivation improved consistently ($F = 75.39$, $p < 0.001$), and creative identity exhibited significant developmental progression ($F = 88.63$, $p < 0.001$). Latent Growth Curve Modeling further revealed that participation in informal learning environments significantly predicted creativity growth trajectories ($\beta = 0.71$, $p < 0.001$), while creative self-efficacy partially mediated relationships between educational participation and creative performance ($\beta = 0.67$, $p < 0.001$). Effect size estimates ranging from 0.85 to 1.49 indicate strong developmental significance across all measured variables.

Correlation analysis identified strong positive relationships among creative self-efficacy, intrinsic motivation, creative identity, collaborative competence, self-regulated learning, and creative thinking. Creative self-efficacy demonstrated a particularly strong relationship with creative identity ($r = 0.91$), while intrinsic motivation correlated substantially with creative thinking ($r = 0.88$). Collaborative competence also demonstrated positive associations with creative performance ($r = 0.86$), indicating that creativity development occurs through coordinated interaction among cognitive, motivational, emotional, and social processes.

Educational participation across multiple learning environments demonstrated equally meaningful relationships with creativity development. School-based inquiry learning correlated positively with creative thinking ($r = 0.82$), extracurricular participation correlated strongly with creative identity ($r = 0.89$), family educational support correlated positively with intrinsic motivation ($r = 0.84$), and participation in digital creative communities correlated significantly with collaborative competence ($r = 0.87$). These findings collectively suggest that creativity emerges through interaction among complementary educational experiences rather than through isolated instructional contexts.

Longitudinal implementation was further illustrated through a case study involving one adolescent participant who demonstrated remarkable creativity development across the three-year investigation. Initially characterized by moderate creative confidence and limited extracurricular participation, the student gradually engaged in school innovation projects, community environmental initiatives, digital design competitions, collaborative maker activities, and youth entrepreneurship programs (Kapoor, 2025; Lindblad, 2025; Stefan, 2023). Continuous portfolio documentation recorded progressive improvement in originality, interdisciplinary thinking, creative communication, collaborative leadership, and reflective problem-solving.

Evaluation demonstrated that the participant's creative thinking score increased from 70.84 to 91.62, while creative self-efficacy improved from 3.28 to 4.84. Teachers observed greater willingness to propose innovative ideas, collaborate across disciplinary boundaries, and persist during challenging design tasks (Corral, 2024; Lin, 2022; Schlimbach, 2023). Parents similarly reported increasing independence, curiosity, resilience, and intrinsic motivation toward authentic problem-solving activities occurring both inside and outside school environments.

Case study findings indicate that creativity develops most effectively when adolescents experience continuous interaction among multiple educational environments supporting experimentation, reflection, collaboration, autonomy, and authentic creative production (Blom, 2025; Daugherity, 2025; Watson, 2024). Formal classroom instruction established foundational knowledge, whereas extracurricular activities, family learning experiences, community participation, and digital creative engagement strengthened creative identity and sustained motivational development. Longitudinal educational continuity therefore amplified developmental growth beyond what isolated classroom instruction could achieve.

Participant experiences further demonstrated that supportive relationships with teachers, family members, peers, and community mentors substantially influenced creativity development. Continuous encouragement, constructive feedback, collaborative opportunities, and authentic recognition strengthened creative confidence while reducing fear of failure during innovation processes. Creativity therefore emerged through reciprocal interaction between individual psychological development and supportive educational ecosystems.

Findings indicate that adolescent creativity should be understood as a multidimensional developmental trajectory extending beyond traditional divergent thinking paradigms. Continuous interaction among formal schooling, informal learning environments, motivational development, creative identity formation, collaborative participation, and educational support significantly strengthened long-term creativity development throughout adolescence. Educational improvement resulted from sustained developmental experiences rather than isolated instructional interventions or cognitive training alone.

Overall results suggest that effective creativity education requires integrated educational ecosystems connecting schools, families, communities, extracurricular organizations, and digital learning environments. Creativity development therefore depends upon coordinated interaction among cognitive growth, psychological development, authentic learning experiences, and supportive social relationships. These findings provide strong empirical evidence supporting longitudinal, learner-centered, and ecosystem-based approaches for cultivating creativity among adolescents in contemporary educational contexts.

Findings demonstrate that adolescent creativity develops as a dynamic and multidimensional trajectory shaped by continuous interaction among formal schooling, informal learning experiences, motivational development, social participation, and personal identity formation. Participants exhibited significant longitudinal improvements in creative thinking, creative self-efficacy, intrinsic motivation, self-regulated learning, creative identity, collaborative competence, and academic achievement throughout the three-year observation period. These results indicate that creativity extends beyond divergent thinking and represents a developmental process influenced by multiple educational ecosystems rather than isolated cognitive abilities.

Quantitative evidence further revealed that adolescents who consistently participated in extracurricular activities, community programs, digital creative platforms, family learning experiences, and collaborative projects demonstrated substantially stronger creativity trajectories than peers whose learning was primarily confined to classroom instruction. Increased participation across multiple educational settings promoted sustained motivational growth and greater willingness to engage with authentic creative challenges. Longitudinal growth therefore reflected cumulative educational experiences rather than temporary instructional effects.

Qualitative findings reinforced the statistical evidence by illustrating that adolescents perceived creativity as closely connected to confidence, autonomy, collaboration, reflection, and opportunities to solve meaningful real-world problems. Participants described creative growth as an evolving process supported by teachers, parents, peers, mentors, and community organizations rather than as an individual cognitive characteristic. Teachers similarly observed

increasing learner initiative, interdisciplinary thinking, resilience, and willingness to experiment with innovative ideas during authentic learning activities.

Overall findings indicate that creativity develops most effectively through coordinated interaction among cognitive development, motivational processes, emotional regulation, collaborative engagement, and supportive educational environments. Educational improvement emerged from continuous participation in diverse learning experiences that collectively strengthened creative identity, learner agency, and adaptive problem-solving. Such findings position creativity as a developmental ecosystem rather than a discrete educational outcome measured through divergent thinking tests alone.

Previous investigations have consistently demonstrated positive relationships between learner-centered pedagogy and creativity development through inquiry-based learning, project-based learning, collaborative learning, and arts education. Findings from the present study support these conclusions while extending existing evidence by demonstrating that creativity evolves longitudinally through sustained interaction among formal schooling, informal learning environments, family engagement, community participation, and digital creative experiences. This developmental perspective broadens current understanding of creativity beyond short-term classroom interventions.

Earlier studies frequently evaluated creativity using cross-sectional designs emphasizing divergent thinking, originality, fluency, flexibility, or immediate instructional outcomes. Results presented here expand those perspectives by incorporating longitudinal assessment of creative identity, creative self-efficacy, intrinsic motivation, emotional engagement, collaborative competence, self-regulated learning, and authentic creative participation across multiple educational environments. Integration of these developmental constructs provides a more comprehensive explanation of creativity growth throughout adolescence.

Differences also emerge regarding the conceptualization of creativity itself. Existing literature often interprets creativity primarily as an individual cognitive ability measured through standardized psychometric instruments. Findings from this study indicate that cognitive ability alone cannot adequately explain creativity development without considering motivational, emotional, social, and contextual influences operating simultaneously across educational ecosystems. Educational participation therefore appears to contribute more substantially to long-term creativity than isolated cognitive training.

Current creativity research frequently investigates schools, families, extracurricular activities, and digital learning as relatively independent educational contexts. Findings demonstrate that creativity develops through continuous interaction among these interconnected environments, where experiences accumulated across settings reinforce one another over time. Such integration advances a broader theoretical understanding of creativity as a developmental process emerging from reciprocal relationships between adolescents and their educational ecosystems.

Observed findings indicate that creativity should be understood as a developmental capability that continuously evolves throughout adolescence rather than as a fixed personal characteristic or isolated cognitive skill. Learners demonstrated stronger creative growth when educational environments consistently encouraged experimentation, reflection, collaboration, and authentic problem-solving while supporting psychological development. Educational transformation therefore requires shifting emphasis from measuring creativity toward cultivating conditions that sustain creativity over time.

Learner experiences further indicate that creative development depends substantially upon identity formation and motivational growth. Adolescents became increasingly willing to generate innovative ideas because they gradually perceived themselves as capable creators, collaborators, and problem-solvers. Creative confidence therefore emerged through repeated opportunities to participate successfully in meaningful educational experiences rather than through isolated creative exercises or talent-based instruction.

Teacher observations similarly indicate that instructional quality remains fundamental to creativity development despite increasing availability of technological learning resources. Educators who intentionally integrated interdisciplinary learning, collaborative inquiry, authentic assessment, reflective dialogue, and constructive feedback achieved stronger developmental outcomes than those emphasizing content transmission alone. Human facilitation therefore continues to play a central role in cultivating adolescent creativity.

Institutional implementation also indicates that sustainable creativity development requires coordinated collaboration among schools, families, communities, extracurricular organizations, cultural institutions, and digital learning platforms. Creativity cannot flourish within isolated educational environments because adolescents continuously construct knowledge through interaction with multiple social and cultural contexts. Educational ecosystems therefore represent essential foundations for long-term creative development.

Educational implications emphasize that creativity should become a longitudinal educational objective integrated across curriculum design, assessment practices, extracurricular programming, community engagement, and digital learning rather than remaining confined to isolated classroom activities. Schools should intentionally create learning environments that encourage exploration, interdisciplinary collaboration, authentic inquiry, learner autonomy, and reflective practice throughout adolescent development. Such implementation strengthens creativity while simultaneously supporting broader educational competencies required in contemporary society.

Practical implications encourage teachers and curriculum developers to redesign instructional experiences that connect classroom learning with authentic community projects, artistic production, scientific inquiry, entrepreneurship, environmental initiatives, and digital innovation. Learning activities should emphasize sustained participation, collaborative creativity, reflective thinking, and real-world problem-solving instead of focusing exclusively on standardized academic performance. Such instructional transformation is expected to produce more meaningful and transferable creative competencies.

Policy implications suggest that educational systems should expand investment in creativity-supportive ecosystems by strengthening partnerships among schools, families, cultural institutions, youth organizations, universities, community learning centers, and digital education providers. Educational policies promoting interdisciplinary learning, project-based instruction, creative assessment, and extracurricular participation will enable adolescents to experience richer opportunities for creativity development across multiple educational environments.

Societal implications extend beyond formal education because creativity represents an essential capacity supporting innovation, entrepreneurship, scientific advancement, civic engagement, cultural participation, and lifelong learning. Educational systems capable of cultivating sustained creativity development therefore contribute directly to social resilience, economic competitiveness, and sustainable human development within increasingly complex global societies.

Improved creativity trajectories primarily resulted from continuous interaction among diverse educational experiences supporting cognitive flexibility, intrinsic motivation, creative confidence, collaborative participation, and reflective learning. Formal schooling established conceptual foundations and structured inquiry, whereas extracurricular activities, family engagement, community participation, and digital creative environments provided authentic opportunities for experimentation and creative expression. Such complementary experiences collectively strengthened long-term creativity development.

Motivational development also contributed substantially because adolescents gradually developed stronger creative self-efficacy and intrinsic motivation through repeated successful participation in meaningful learning activities. Positive educational experiences increased willingness to take intellectual risks, persist through uncertainty, collaborate with peers, and

explore innovative solutions. Psychological growth therefore reinforced creative performance throughout the longitudinal observation period.

Supportive social relationships significantly influenced developmental outcomes because teachers, parents, mentors, peers, and community members continuously provided encouragement, constructive feedback, emotional support, and opportunities for authentic participation. These interpersonal relationships reduced fear of failure while strengthening adolescents' confidence to engage in increasingly complex creative activities. Social support therefore functioned as a critical mechanism underlying sustained creativity development.

Coordinated interaction among cognitive growth, motivational development, identity formation, emotional regulation, collaborative learning, and educational opportunity ultimately explains why adolescents participating across multiple learning environments demonstrated significantly stronger creativity trajectories than peers whose experiences remained predominantly classroom-based. Educational diversity generated cumulative developmental advantages that exceeded the influence of any individual instructional intervention.

Future investigations should examine creativity development across longer developmental periods extending from early adolescence into adulthood to determine how educational experiences influence lifelong creative trajectories, career development, innovation capacity, and professional achievement. Longitudinal investigations spanning multiple developmental stages would provide stronger evidence regarding sustained creativity growth beyond secondary education.

Emerging technologies including artificial intelligence, immersive learning environments, virtual reality, augmented reality, maker technologies, and collaborative digital platforms present valuable opportunities for expanding creativity research. Future studies should investigate how intelligent educational technologies support personalized creativity development, interdisciplinary innovation, collaborative knowledge creation, and authentic creative production while preserving learner autonomy and intrinsic motivation.

Implementation-oriented investigations deserve continued attention as educational systems increasingly prioritize creativity within curriculum reform and competency-based education. Future research should evaluate teacher professional development, curriculum integration, assessment innovation, educational leadership, family engagement, cultural diversity, digital participation, and policy implementation influencing sustainable creativity development across diverse educational contexts.

Interdisciplinary collaboration among developmental psychologists, educational psychologists, creativity researchers, learning scientists, neuroscientists, curriculum specialists, educators, sociologists, and policymakers will be essential for advancing creativity research. Continued integration of developmental psychology, educational ecology, learning sciences, digital pedagogy, and creativity studies will support the development of comprehensive educational ecosystems capable of nurturing lifelong creativity, adaptive expertise, and innovative citizenship in future generations.

CONCLUSION

Findings demonstrate that adolescent creativity develops through a dynamic and longitudinal interaction among cognitive growth, creative self-efficacy, intrinsic motivation, creative identity, collaborative engagement, and educational experiences across formal and informal learning environments. Distinctive evidence from this study indicates that creativity cannot be sufficiently explained by divergent thinking alone but should instead be understood as a multidimensional developmental trajectory shaped by sustained participation in schools, families, extracurricular activities, community programs, and digital creative ecosystems. Stronger creativity trajectories emerged among adolescents who experienced continuous opportunities for authentic problem-solving, interdisciplinary collaboration, reflective practice,

and learner autonomy across multiple educational contexts. This developmental perspective redefines creativity as an evolving educational capability supported by interconnected learning environments rather than as an isolated cognitive attribute measured through standardized creativity tests.

Scientific contribution of this research extends both conceptually and methodologically. Conceptually, the study proposes an integrated developmental framework that connects creativity, educational psychology, developmental psychology, creative identity, intrinsic motivation, self-regulated learning, collaborative competence, and educational ecology into a unified explanatory model of adolescent creativity development. Methodologically, the mixed-methods longitudinal sequential explanatory design combines repeated quantitative assessments, latent growth modeling, structural equation modeling, portfolio analysis, classroom observations, family interviews, community participation records, reflective journals, and qualitative narrative inquiry to generate comprehensive evidence regarding creativity trajectories over time. Integration of longitudinal quantitative and qualitative findings provides a robust explanation of the mechanisms through which multiple educational environments collectively nurture sustained creativity, offering practical guidance for educators, curriculum developers, school leaders, families, community organizations, and policymakers.

Scope of this investigation remains limited to adolescents enrolled in selected secondary schools observed over a three-year period within specific educational and sociocultural contexts. Differences in cultural background, educational policy, technological access, family environments, community resources, and institutional characteristics may influence the transferability of these findings to other populations and educational systems. Future research should therefore examine creativity development across longer developmental periods, diverse cultural settings, interdisciplinary educational contexts, and emerging digital learning ecosystems while incorporating artificial intelligence–supported creativity assessment, learning analytics, immersive technologies, and cross-national longitudinal comparisons to strengthen understanding of lifelong creativity development within increasingly complex educational environments.

DECLARATION OF AI AND AI ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this work, the author(s) used ChatGPT (OpenAI) to assist with language refinement, improving clarity, grammatical accuracy, and the overall organization of the manuscript. After using this tool, the author(s) carefully reviewed, verified, and edited the generated content as necessary and take(s) full responsibility for the accuracy, integrity, and final content of the publication.

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AUTHOR CONTRIBUTIONS

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.

Author 2: Conceptualization; Data curation; In-vestigation.

Author 3: Data curation; Investigation.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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