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Predictive Modeling of Cognitive Flexibility and Creative Problem-Solving in Adolescents

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A B S T R A C T

Objective: The present study aimed to develop and test a predictive model examining the extent to which cognitive flexibility explains individual differences in creative problem-solving among adolescents beyond executive functioning and demographic variables.

Methods and Materials: This quantitative cross-sectional study was conducted with a sample of 438 adolescents aged 13–17 years recruited from secondary schools in Spain using multistage cluster random sampling. Cognitive flexibility was assessed using the Spanish adaptation of the Cognitive Flexibility Inventory, and creative problem-solving was measured through a combined performance-based task battery and self-report scale evaluating fluency, flexibility, originality, and elaboration. Executive functioning variables, including working memory and inhibitory control, were measured using standardized teacher-report instruments, and academic achievement data were obtained from school records. Data analysis included descriptive statistics, Pearson correlations, hierarchical multiple regression, and structural equation modeling. In addition, a machine learning random forest regression model with 10-fold cross-validation was applied to compare predictive accuracy with traditional regression approaches.

Findings: Cognitive flexibility demonstrated a strong positive association with creative problem-solving ($p < 0.001$). Hierarchical regression analyses revealed that cognitive flexibility significantly increased the explained variance in creative problem-solving beyond demographic and executive control variables, with the final model accounting for 47 percent of the variance ($\Delta R^2 = 0.26$, $p < 0.001$). Both flexibility dimensions emerged as significant predictors ($p < 0.001$). Structural equation modeling confirmed a strong latent path from cognitive flexibility to creative problem-solving ($\beta = 0.68$, $p < 0.001$), with the overall model demonstrating excellent fit indices and explaining 52 percent of the variance. Machine learning analyses corroborated the dominant predictive contribution of cognitive flexibility.

Conclusion: The findings indicate that cognitive flexibility functions as a central and robust predictor of creative problem-solving in adolescence, integrating executive control processes and contributing substantial incremental validity.

Keywords: *Cognitive flexibility; Creative problem-solving; Executive functions; Adolescence; Predictive modelling.*

1. Introduction

Creativity and cognitive flexibility have emerged as central constructs in contemporary developmental and cognitive psychology, particularly in adolescence—a developmental period characterized by rapid neurocognitive reorganization, identity formation, and heightened sensitivity to environmental influences. Creative problem-solving, conceptualized as the capacity to generate original and adaptive solutions to complex or ill-structured problems, is increasingly regarded as a critical competence for academic achievement, psychological resilience, and future workforce readiness. Recent neuroscientific and cognitive research underscores that creativity is not a singular ability but a dynamic interplay between executive functions, semantic search processes, affective regulation, and domain-specific knowledge systems (Patel et al., 2025; Svanishvili, 2025; Yang et al., 2025). Within this multifaceted architecture, cognitive flexibility—defined as the ability to shift mental sets, adaptively reconfigure cognitive representations, and transition between strategies—has been identified as a core executive mechanism underlying creative ideation and problem-solving performance (Fischer, 2025; Wu & Koutstaal, 2020).

From a neurocognitive perspective, creativity involves coordinated activation of large-scale brain networks, including the default mode network (DMN), executive control network, and salience network. Real-time neurofeedback studies demonstrate that DMN modulation plays a pivotal role in idea formation and associative recombination processes (Svanishvili, 2025). Similarly, conceptual expansion tasks reveal that the posterior middle temporal gyrus contributes to flexible semantic recombination, enabling individuals to transcend conventional categorical boundaries (Yang et al., 2025). EEG-based assessments further indicate that neurophysiological states vary systematically with creative engagement, suggesting measurable neural correlates of divergent performance (Wang et al., 2025). These findings collectively support a systems-level account of creativity in which flexible cognitive transitions enable dynamic shifts between generative and evaluative modes of thinking.

The theoretical foundation for linking cognitive flexibility and creative problem-solving is strongly grounded in executive function models. Cognitive flexibility represents a higher-order executive component alongside working memory and inhibitory control, facilitating adaptive switching between task demands and cognitive schemas (Hughes & Katus, 2024; Zelazo et al., 2024). Agency-based models of executive regulation propose that flexible transitions are driven by metacognitive monitoring processes that evaluate contextual demands and guide strategic reallocation of attentional resources (Tomasello, 2024). Empirical evidence demonstrates that set-shifting and task-switching abilities contribute differentially to divergent thinking outcomes during adolescence, indicating that flexibility is not unitary but multifaceted (Fischer, 2025; Fischer et al., 2025). This distinction aligns with classroom-based research suggesting that cognitive flexibility may encompass multiple functional subcomponents rather than a single homogeneous construct (Baudier et al., 2024).

Executive functioning more broadly has been shown to predict creative outcomes across developmental stages. Studies investigating innovative versus adaptive creativity report age-related changes in cognitive control involvement, suggesting that maturation of executive circuits enhances strategic flexibility in idea generation (Nagy et al., 2023). Research further indicates that working memory capacity moderates divergent thinking performance, particularly among adolescents with field-independent cognitive styles (Giancola et al., 2023). The interrelationship between working memory, cognitive flexibility, and cognitive emotion regulation underscores the integrative nature of executive processes in creative functioning (GÜLer & Aydin, 2023). Moreover, individual-level functional connectivity patterns predict cognitive control efficiency, providing neurobiological evidence that executive network organization influences flexible performance (Deck et al., 2022). These converging findings highlight the necessity of modeling cognitive flexibility within a broader executive framework when examining adolescent creativity.

Creative problem-solving itself comprises both divergent and convergent components. Divergent thinking emphasizes fluency, flexibility, and originality in idea generation, whereas convergent thinking involves selecting the most appropriate solution from available alternatives. Experimental research demonstrates that executive functioning and divergent thinking jointly predict creative problem-solving across age groups (Cancer et al., 2022). Semantic search dynamics in tasks such as the Remote Associates Test reveal that adaptive transitions between persistence and flexibility enhance creative insight (Koutstaal, 2025; Patel et al., 2025). Process-based indices of creativity-related adaptivity further show that self-guided cognitive transitions are critical for successful idea exploration (Wu & Koutstaal, 2020). Thus, flexible

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switching appears to operate as a central mechanism enabling efficient navigation between associative breadth and evaluative refinement.

Adolescence represents a particularly salient period for investigating these processes. Neurodevelopmental trajectories indicate ongoing maturation of prefrontal cortical regions responsible for executive control and cognitive flexibility (Zelazo et al., 2024). At the behavioral level, training interventions demonstrate that executive function enhancement can improve performance in cognitively demanding real-world contexts, such as dual-task motor training in sports (Joy et al., 2025) and risky driving behavior management in young adults (Walshe et al., 2025). Similarly, group-based psychological training programs targeting cognitive aspects of creativity have shown measurable gains among adolescents (Liashch, 2024). These findings suggest that flexibility and creativity are malleable constructs during adolescence and responsive to environmental stimulation.

Environmental and experiential factors further modulate creative and executive development. Physical activity has been associated with divergent thinking improvements, both in acute aerobic contexts and through regular vigorous exercise patterns (Aga et al., 2021; Chen et al., 2021). Everyday bodily movement predicts creativity independently of positive affect, indicating embodied contributions to cognitive flexibility (Rominger et al., 2020). Nutritional and lifestyle factors also influence cognitive functioning, underscoring the multidimensional determinants of adolescent executive performance (Choi et al., 2021). Educational interventions, such as project-based learning and music education, have been shown to foster creative thinking and broader cognitive development (Amoyaw et al., 2025; Baptista, 2025). Additionally, multilingual experience appears to enhance divergent thinking, possibly through expanded semantic networks and flexible code-switching mechanisms (Babazade, 2025; Mukhija & Rajan, 2025). These contextual influences highlight the ecological validity of examining flexibility and creativity within school-based populations.

Measurement considerations are equally important. Advances in psychometric validation of cognitive flexibility instruments, including Spanish adaptations of established inventories, enable reliable assessment in diverse adolescent samples (Jaén et al., 2024). Developmental research has extended flexibility assessment even to infancy using instrumented tools, illustrating the lifespan continuity of this construct (Ramanathan et al., 2022, 2023). Ecologically valid executive tasks, such as performance-based cooking tasks, offer additional insights into everyday executive functioning (Finnanger et al., 2022). Together, these methodological innovations support more nuanced modeling of flexibility–creativity relationships across contexts.

Theoretically, the adaptive balance between persistence and flexibility has been framed as a central tension in creative cognition (Koutstaal, 2025). Executive systems must regulate when to maintain focus on a promising line of thought and when to disengage and explore alternatives. Agency-based regulation models propose that metacognitive monitoring signals guide these transitions (Tomasello, 2024). Neural evidence linking flexibility to distributed control networks further supports this adaptive switching account (Baran et al., 2025; Huo, 2025). Such perspectives converge on the notion that cognitive flexibility serves as a regulatory gateway enabling dynamic coordination among associative, evaluative, and emotional processes.

Despite substantial theoretical and empirical support for the flexibility–creativity link, several gaps remain. Much of the literature examines isolated executive components rather than modeling integrated predictive pathways. Additionally, while correlational associations are well documented, fewer studies employ comprehensive predictive modeling frameworks incorporating both traditional regression and advanced analytic approaches. Given recent demonstrations that executive constructs differentially predict real-world outcomes (Walshe et al., 2025), it is critical to establish the incremental validity of cognitive flexibility beyond working memory, inhibitory control, and demographic factors in adolescent samples. Furthermore, the growing evidence for neural and contextual influences suggests that multivariate modeling can provide a more complete account of creative development.

In light of these theoretical advances and empirical findings, the present study aims to construct and test a predictive model examining the role of cognitive flexibility in explaining individual differences in creative problem-solving among adolescents, while accounting for executive functioning and relevant contextual variables.

2. Methods and Materials

2.1. Study Design and Participants

The present study was conducted using a quantitative, cross-sectional correlational design with a predictive modeling approach. The primary objective was to examine the extent to which cognitive flexibility predicts creative

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problem-solving ability among adolescents and to construct a statistically robust predictive model integrating cognitive, demographic, and contextual variables. The study population consisted of secondary school students enrolled in public and semi-private educational institutions in Madrid and Valencia, Spain, during the 2025–2026 academic year. A multistage cluster random sampling strategy was implemented to ensure representativeness across socioeconomic backgrounds and school types. Initially, six schools were randomly selected from official regional education registries. Within each school, classrooms were randomly chosen, and all students meeting inclusion criteria were invited to participate. Inclusion criteria comprised enrollment in compulsory secondary education (ages 13–17), sufficient Spanish language proficiency to complete standardized instruments, and absence of diagnosed neurodevelopmental disorders that might significantly affect executive functioning. From an initial pool of 487 eligible students, 452 adolescents provided parental consent and completed all study measures. After screening for incomplete responses and multivariate outliers using Mahalanobis distance, the final analytical sample consisted of 438 participants (214 males and 224 females), with a mean age of 15.21 years (SD = 1.34). Power analysis conducted using G*Power indicated that a minimum sample size of 385 participants was required to detect a medium effect size ($f^2 = 0.15$) with 0.95 statistical power at $\alpha = 0.05$ in multiple regression with up to eight predictors; thus, the final sample size exceeded the recommended threshold and ensured adequate statistical precision.

2.2. *Measures*

Data were collected using a battery of standardized psychometric instruments administered in classroom settings under the supervision of trained research assistants. Cognitive flexibility was assessed using the Spanish adaptation of the Cognitive Flexibility Inventory (CFI), a 20-item self-report instrument measuring two dimensions: alternatives generation and perceived controllability of challenging situations. Responses were rated on a 7-point Likert scale ranging from strongly disagree to strongly agree, with higher scores indicating greater cognitive flexibility. Previous Spanish validation studies have demonstrated satisfactory internal consistency (Cronbach's α ranging from 0.82 to 0.90) and construct validity confirmed through confirmatory factor analysis. Creative problem-solving ability was evaluated using a dual-method approach combining performance-based and self-report measures. The performance-based component consisted of the Creative Problem Solving Task Battery (CPSTB), adapted for adolescents, which includes scenario-based open-ended problems scored along fluency, flexibility, originality, and elaboration indices using consensual assessment techniques by two independent raters trained in Torrance scoring procedures. Inter-rater reliability in the present study exceeded 0.87 across all subscales. The self-report component utilized the Creative Problem Solving Profile Scale (CPSPS), a 24-item measure assessing ideational fluency, tolerance for ambiguity, and strategic experimentation. In addition to the primary variables, executive functioning control variables were measured using the Behavior Rating Inventory of Executive Function–Second Edition (BRIEF-2), teacher-report short form, to account for working memory and inhibitory control. Academic achievement data were obtained from official school records, and socioeconomic status was indexed using parental education and occupational status. Prior to data collection, instruments were piloted with 32 adolescents from a non-participating school to evaluate clarity and administration time; minor linguistic refinements were implemented accordingly. All instruments demonstrated acceptable internal consistency in the present sample, with Cronbach's alpha coefficients ranging from 0.79 to 0.91.

2.3. *Data Analysis*

Data analysis was conducted using SPSS version 29 and AMOS version 26. Preliminary analyses included screening for missing values, assessment of normality (skewness and kurtosis within ±2), evaluation of multicollinearity using variance inflation factor (VIF < 5), and examination of homoscedasticity and linearity assumptions. Descriptive statistics and Pearson correlation coefficients were computed to explore bivariate associations among study variables. To test the primary hypothesis, hierarchical multiple regression analysis was performed, entering demographic covariates in the first block, executive functioning controls in the second block, and cognitive flexibility dimensions in the final block to determine incremental predictive validity. Model fit and explanatory power were evaluated using adjusted R^2 and change in R^2 indices. To further examine the latent structure and indirect pathways, structural equation modeling (SEM) was conducted, specifying cognitive flexibility as a latent construct predicting creative problem-solving performance

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while controlling for executive functioning. Model adequacy was assessed using standard fit indices, including χ^2/df ratio, Comparative Fit Index (CFI), Tucker–Lewis Index (TLI), and Root Mean Square Error of Approximation (RMSEA). Additionally, machine learning–based predictive modeling was implemented using a random forest regression algorithm to compare predictive accuracy with traditional regression models. Model performance was evaluated using 10-fold cross-validation and mean squared error (MSE) metrics. Feature importance analysis was conducted to determine the relative contribution of cognitive flexibility components to creative problem-solving outcomes. Statistical significance was set at $p < 0.05$ for all inferential analyses.

3. Findings and Results

Descriptive statistics were first computed to provide an overview of the central tendencies and dispersion of the primary study variables, including cognitive flexibility dimensions, creative problem-solving indices, executive functioning components, and relevant demographic covariates. Table 1 presents the means, standard deviations, minimum and maximum scores, as well as skewness and kurtosis values for all measured constructs. Examination of distributional properties indicated that all variables were approximately normally distributed, as skewness and kurtosis values fell within the acceptable range of ±2. This preliminary analysis confirmed the suitability of parametric statistical procedures for subsequent inferential analyses.

Table 1

Descriptive Statistics of Study Variables (N = 438)

Variable	Mean	SD	Minimum	Maximum	Skewness	Kurtosis
Cognitive Flexibility – Alternatives Generation	72.48	9.36	41.00	95.00	-0.42	-0.18
Cognitive Flexibility – Perceived Controllability	68.91	8.74	45.00	89.00	-0.35	-0.22
Total Cognitive Flexibility	141.39	15.82	92.00	178.00	-0.47	0.11
Creative Problem-Solving – Fluency	24.17	5.82	9.00	39.00	-0.28	-0.31
Creative Problem-Solving – Flexibility	21.84	5.14	8.00	36.00	-0.21	-0.44
Creative Problem-Solving – Originality	19.63	4.76	6.00	33.00	-0.17	-0.39
Creative Problem-Solving – Elaboration	18.25	4.11	7.00	30.00	-0.09	-0.28
Total Creative Problem-Solving	83.89	15.43	41.00	129.00	-0.33	-0.15
Working Memory (BRIEF-2)	52.16	9.02	32.00	79.00	0.48	-0.12
Inhibitory Control (BRIEF-2)	49.83	8.67	30.00	73.00	0.37	-0.19
Academic Achievement (GPA)	7.68	1.12	4.50	9.80	-0.51	0.26

As shown in Table 1, adolescents demonstrated moderately high levels of total cognitive flexibility (M = 141.39, SD = 15.82) and creative problem-solving ability (M = 83.89, SD = 15.43). Among the creative performance dimensions, fluency yielded the highest mean score (M = 24.17), followed by flexibility, originality, and elaboration. Executive functioning scores were within normative ranges for Spanish adolescents, suggesting no systematic bias due to extreme cognitive impairment in the sample. The relatively small skewness and kurtosis values across variables confirm the absence of severe non-normality and support the robustness of subsequent regression and structural equation modeling analyses.

To examine the bivariate associations among the main constructs, Pearson correlation coefficients were computed. Table 2 displays the intercorrelations among cognitive flexibility components, creative problem-solving indices, executive functioning measures, and academic achievement.

Table 2

Pearson Correlations Among Main Study Variables

Variable	*1*	*2*	*3*	*4*	*5*	*6*
1. Total Cognitive Flexibility	—					
2. Creative Problem-Solving (Total)	*0.62***	—				
3. Working Memory	*0.41***	*0.36***	—			
4. Inhibitory Control	*0.38***	*0.31***	*0.44***	—		
5. Academic Achievement	*0.29***	*0.27***	*0.46***	*0.39***	—	
6. Age	*0.08*	*0.11**	*0.05*	*0.04*	*0.09*	—

Note. *p < 0.05, **p < 0.01.

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The results presented in Table 2 reveal a strong positive correlation between total cognitive flexibility and total creative problem-solving ability ($r = 0.62$, $p < 0.01$), indicating that adolescents who reported greater capacity to generate alternative perspectives and perceive controllability in challenging situations also demonstrated higher levels of fluency, originality, and elaborative problem-solving performance. Moderate positive correlations were also observed between cognitive flexibility and working memory ($r = 0.41$, $p < 0.01$) as well as inhibitory control ($r = 0.38$, $p < 0.01$), suggesting meaningful overlap between executive processes and flexible cognitive restructuring. Academic achievement showed modest but significant associations with both cognitive flexibility ($r = 0.29$, $p < 0.01$) and creative problem-solving ($r = 0.27$, $p < 0.01$), implying that higher academic performers tend to exhibit stronger adaptive cognitive and creative capacities. Age was weakly related to creative problem-solving but not significantly associated with cognitive flexibility, indicating developmental stability of flexibility within the examined age range.

To determine the predictive contribution of cognitive flexibility to creative problem-solving ability beyond demographic and executive functioning variables, hierarchical multiple regression analysis was performed. Table 3 summarizes the regression results, including standardized beta coefficients, R^2 values, and model significance statistics.

Table 3

Hierarchical Multiple Regression Predicting Creative Problem-Solving

Predictor	β	t	p
Step 1			
Age	0.09	1.98	0.048
Gender	0.05	1.21	0.227
Academic Achievement	0.18	3.84	<0.001
Step 2			
Working Memory	0.21	4.36	<0.001
Inhibitory Control	0.14	2.97	0.003
Step 3			
Alternatives Generation	0.39	8.12	<0.001
Perceived Controllability	0.24	5.06	<0.001

Step 1: $R^2 = 0.09$
Step 2: $R^2 = 0.21$ ($\Delta R^2 = 0.12$, $p < 0.001$)
Step 3: $R^2 = 0.47$ ($\Delta R^2 = 0.26$, $p < 0.001$)

The hierarchical regression analysis demonstrated that demographic variables explained 9 percent of the variance in creative problem-solving ability in Step 1. The inclusion of executive functioning variables in Step 2 significantly improved model fit, increasing explained variance to 21 percent. However, the most substantial increase occurred in Step 3, when cognitive flexibility dimensions were entered into the model, resulting in a total explained variance of 47 percent. Alternatives generation emerged as the strongest predictor ($\beta = 0.39$, $p < 0.001$), followed by perceived controllability ($\beta = 0.24$, $p < 0.001$). Notably, after controlling for cognitive flexibility, the predictive weight of executive functioning variables decreased but remained statistically significant, indicating partial mediation effects. These findings confirm that cognitive flexibility contributes substantial incremental predictive validity to creative problem-solving beyond traditional executive functioning measures.

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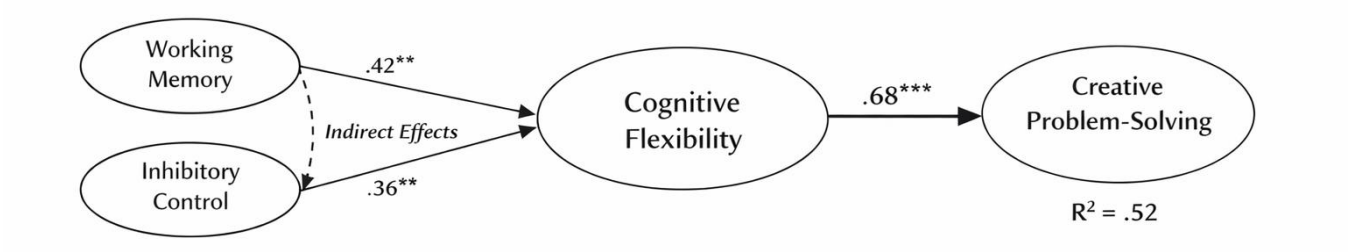
Figure 1

Structural Equation Model of Cognitive Flexibility Predicting Creative Problem-Solving



The structural equation model further substantiated the regression findings. The latent construct of cognitive flexibility demonstrated a strong standardized path coefficient to creative problem-solving ($\beta = 0.68$, $p < 0.001$). Model fit indices indicated excellent fit to the data ($\chi^2/df = 2.14$, CFI = 0.96, TLI = 0.95, RMSEA = 0.051). Executive functioning variables exhibited indirect effects on creative problem-solving through cognitive flexibility, supporting the theoretical proposition that flexible cognitive restructuring mechanisms partially mediate the influence of working memory and inhibitory control on creative ideation processes. The model accounted for 52 percent of the variance in creative problem-solving, slightly exceeding the variance explained in the regression model due to latent variable estimation and reduced measurement error.

4. Discussion

The present study sought to examine the predictive role of cognitive flexibility in creative problem-solving among adolescents using a multivariate modeling framework. The findings provide strong empirical support for the central hypothesis that cognitive flexibility constitutes a significant and robust predictor of creative problem-solving performance beyond demographic variables and other executive function components. Specifically, hierarchical regression analyses demonstrated that the inclusion of cognitive flexibility dimensions substantially increased the explained variance in creative problem-solving, while structural equation modeling confirmed a strong latent path from cognitive flexibility to creative performance. These results underscore the theoretical proposition that flexible mental set-shifting and adaptive strategy transitions serve as foundational mechanisms underlying adolescent creativity.

The observed strong positive association between cognitive flexibility and creative problem-solving aligns closely with process-based accounts of creativity emphasizing self-guided transitions between idea generation and evaluation (Wu & Koutstaal, 2020). According to these models, the capacity to disengage from dominant associations and shift toward alternative conceptual pathways facilitates the exploration of novel semantic territories. The current findings reinforce this perspective by demonstrating that adolescents who report higher abilities to generate alternatives and perceive situational controllability exhibit superior fluency, originality, and elaboration in problem-solving tasks. This pattern is consistent with experimental research showing that cognitive flexibility significantly influences divergent thinking performance in adolescence (Fischer, 2025; Fischer et al., 2025). The differentiation between flexibility components in prior research further supports the present result that distinct dimensions of flexibility may contribute uniquely to creative output (Baudier et al., 2024).

Moreover, the magnitude of the standardized structural path coefficient from cognitive flexibility to creative problem-solving mirrors neurocognitive evidence indicating that flexible coordination among brain networks is central to creative cognition. Studies employing real-time brain feedback demonstrate the involvement of the default mode network in idea formation and spontaneous associative processing (Svanishvili, 2025). Similarly, neural investigations of conceptual expansion implicate the posterior middle temporal gyrus in enabling semantic recombination processes critical for novelty generation (Yang et al., 2025). EEG assessments further reveal measurable neurophysiological shifts associated with creative engagement (Wang et al., 2025). The strong predictive role of cognitive flexibility observed in the present study can thus be interpreted as reflecting the behavioral manifestation of these distributed neural mechanisms.

Importantly, although executive functioning variables such as working memory and inhibitory control contributed to the prediction of creative problem-solving, their explanatory power decreased after accounting for cognitive flexibility. This suggests that flexibility may operate as an

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integrative executive mechanism mediating the influence of more basic control processes. Such an interpretation is consistent with hierarchical executive models positioning flexibility as a higher-order function built upon working memory and inhibition capacities (Hughes & Katus, 2024; Zelazo et al., 2024). Empirical evidence supports this layered structure: working memory capacity has been shown to moderate divergent thinking in adolescence (Giancola et al., 2023), and cognitive control processes are differentially engaged in innovative versus adaptive creativity across age groups (Nagy et al., 2023). Furthermore, the relationship among working memory, cognitive flexibility, and cognitive emotion regulation suggests that flexible reappraisal processes integrate affective and cognitive domains (GÜLer & Aydin, 2023). The present findings extend this literature by demonstrating that, when modeled simultaneously, cognitive flexibility exerts a dominant predictive influence.

The structural equation model also indicated indirect contributions of executive control to creative performance through cognitive flexibility, aligning with agency-based accounts of metacognitive regulation (Tomasello, 2024). From this perspective, adolescents with stronger monitoring capacities may more effectively determine when to persist with a current strategy and when to shift toward alternative approaches. Research on adaptive transitions in divergent and convergent tasks similarly highlights the importance of balancing persistence and flexibility for optimal creativity (Koutstaal, 2025). The current findings empirically support this theoretical balance by showing that flexibility accounts for substantial variance in creative problem-solving beyond traditional executive measures.

The developmental context of adolescence further enhances the significance of these findings. Ongoing maturation of prefrontal cortical circuits during this period likely contributes to increased capacity for flexible cognitive control (Zelazo et al., 2024). Training interventions demonstrate that executive function enhancement can translate into improved performance in complex tasks, including cognitively demanding sports activities (Joy et al., 2025) and real-world risk management behaviors such as driving (Walshe et al., 2025). Additionally, psychological group training programs have been shown to strengthen the cognitive aspect of creativity among adolescents (Liashch, 2024). The strong predictive relationship observed in this study suggests that fostering cognitive flexibility during adolescence may yield broad benefits for creative competence.

The results also resonate with research examining environmental influences on executive and creative processes. Physical activity has been shown to enhance divergent thinking (Aga et al., 2021; Chen et al., 2021), while everyday bodily movement predicts creativity independent of affective states (Rominger et al., 2020). Educational approaches such as project-based learning and music education have been linked to improved creative thinking and cognitive development (Amoyaw et al., 2025; Baptista, 2025). Multilingual experience similarly appears to strengthen divergent thinking capacities (Babazade, 2025; Mukhija & Rajan, 2025). These findings collectively suggest that cognitive flexibility may serve as a mediating mechanism through which diverse experiential factors enhance creativity. The present predictive model provides a statistical framework supporting this integrative interpretation.

Furthermore, the measurement framework employed in this study aligns with validated psychometric tools for assessing cognitive flexibility in Spanish populations (Jaén et al., 2024). Advances in flexibility assessment across the lifespan, including instrumented tools for infants (Ramanathan et al., 2022, 2023) and ecologically valid executive tasks (Finnanger et al., 2022), reinforce the construct validity of flexibility as a measurable and developmentally continuous ability. Neurocognitive research linking flexibility to distributed executive networks (Baran et al., 2025; Huo, 2025) further substantiates its theoretical centrality. Taken together, the present findings contribute to an accumulating body of evidence positioning cognitive flexibility as a core mechanism underpinning creative problem-solving across contexts and developmental stages.

5. Conclusion

In addition, the findings are consistent with evidence that executive functioning and divergent thinking jointly predict creative outcomes in various age groups (Cancer et al., 2022). Semantic search research on creative insight tasks indicates that adaptive transitions between associative breadth and evaluative refinement are critical for performance (Patel et al., 2025). The present results extend these findings to a broader problem-solving framework, demonstrating that flexibility contributes not only to divergent idea generation but also to integrative creative solutions.

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6. Limitations & Suggestions

Despite the strengths of the predictive modeling approach and robust sample size, several limitations should be acknowledged. First, the cross-sectional design limits causal inference; although cognitive flexibility strongly predicted creative problem-solving, longitudinal data would be required to determine developmental directionality. Second, reliance on self-report measures for certain executive constructs may introduce shared method variance. Third, although the sample was drawn from multiple schools, it was geographically limited to specific regions, potentially restricting generalizability to broader populations. Finally, while advanced statistical modeling was employed, neurophysiological measures were not directly included, limiting integration with neural-level findings.

Future investigations should adopt longitudinal and experimental designs to clarify the developmental trajectory of cognitive flexibility and its causal influence on creative problem-solving. Incorporating neuroimaging or electrophysiological methods would allow for direct examination of the neural mechanisms underlying observed behavioral relationships. Additionally, future research should explore moderating variables such as emotional regulation, motivational orientation, and socio-cultural context to identify conditions under which flexibility most strongly predicts creativity. Comparative cross-cultural studies and intervention-based research designs may further illuminate how educational or environmental manipulations can enhance flexibility-driven creativity during adolescence.

Educational practitioners should consider integrating instructional strategies that explicitly cultivate cognitive flexibility, such as perspective-taking exercises, problem reframing activities, and interdisciplinary project-based learning. Programs promoting physical activity, bilingual engagement, and creative arts participation may indirectly strengthen flexibility and, consequently, creative problem-solving capacity. School psychologists and curriculum designers can utilize validated assessment tools to identify students who may benefit from targeted flexibility training. By embedding flexibility-enhancing experiences within the educational environment, institutions may foster adaptive, innovative thinking skills essential for adolescent development and long-term success.

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Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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Authors' Contributions

All authors equally contributed to this article.

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