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Review

Neurocognitive Profile of Creativity in Improving Academic Performance—A Scoping Review

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Abstract: The present study provides an in-depth review of the neurocognitive aspects of creativity and its association with academic achievement in children. The outcomes of this study indicate a considerable positive relationship between creativity and academic ability, namely in reading, comprehension, and written tasks. Neurocognitive processes, including associative thinking, divergent thinking, executive functions, and predictive representations, play a significant role in shaping the characteristics associated with creativity. Although creativity may lead to potential adverse outcomes, extensive study has firmly established its significance in academic accomplishment. This systematic review includes studies conducted between the years 2016 and 2022. The primary selection criteria employed for the inclusion of articles in the research encompassed the following aspects: articles written in the English language, articles directly relevant to the subject matter of the study, articles featuring a sample population comprising students, displaying regular and typical developmental patterns, articles adopting a descriptive, exploratory, or longitudinal study design. The research promotes the cultivation of creativity within educational settings, emphasizing the utilization of cultural resources, the alignment of teachers' attitudes with the promotion of creativity, and the comprehension of neurocognitive factors influencing creative processes. There is a significant focus on the necessity for more investigation into the correlation between creativity and academic achievement. Further research is needed to gain a comprehensive understanding of how creativity is incorporated within educational settings to achieve academic performance.

Keywords: creativity; academic performance; neurocognition; learning; academic skills

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1. Introduction

Creativity is a cognitively complex process that generates novel and valuable ideas, solutions, and products. It is essential in numerous facets of human life, including academic performance and education. Creativity as a means of enhancing academic performance is gaining increasing attention in research and education.

Several brain regions, including the prefrontal cortex, anterior cingulate cortex, and default mode network, have been linked to creative thought in neurocognitive studies of the brain processes underlying creativity. These regions are associated with various cognitive functions, such as ideation, cognitive flexibility, and problem-solving.

The relationship between creativity and academic achievement is complex and can vary depending on the context and the specific measures of creativity and academic achievement employed in the studies. Here are some potential influences of creativity on academic performance:

Enhanced Problem-Solving: Through creative thinking, students can approach problems in novel ways and generate inventive solutions. This can be especially beneficial in subjects that require solving complex problems, such as mathematics and science.

Enhanced Learning and Memory Consolidation: Creative activities can improve learning and memory consolidation. When students actively engage in creative tasks related to

the topic, they may better comprehend and retain the information. Incorporating creative elements into the instructional process can increase student motivation and engagement. Students become more invested in their studies when encouraged to explore and express their ideas creatively.

Communication and Expression: Creativity can improve both written and verbal communication skills. Students who can express themselves creatively may excel in subjects that require effective communication, such as literature, writing, and the arts.

Engaging in creative activities can aid in reducing stress and anxiety, which can positively affect academic performance.

Recognizing that the connection between creativity and academic performance can be complex is essential. Creativity can have positive effects, but an imbalanced emphasis on creative activities at the expense of traditional academic subjects can have negative consequences.

According to [1], creativity is a complex and multifaceted process that involves identifying information gaps, formulating hypotheses about them, analyzing and testing them, and communicating the results to solve problems and promote environmental changes. According to research findings, creativity is also associated with school performance and academic accomplishments, such as arithmetic, writing, and reading [2–4]. In addition, juvenile creativity undergoes various developmental changes, including a decline during elementary school [5]. Characteristics such as acquired knowledge, methods of thinking, verbal and language skills, types of stimulation, and motivation are also responsible for a child's creativity performance throughout his or her development [6]. It also appears to be associated with reading, critical thinking, reasoning, creativity, and freedom of expression [7]. Lastly, thinking and creating original products and new ideas are among the skills that distinguish humans from other species and have brought them to their current position. According to this meta-analysis, creative ability is a component of the school experience and the development of cognitive skills and a factor that promotes excellent academic performance [8].

According to several researchers, creativity and learning entailed change and had fundamental parallels [2,9–11]. Specifically, creativity is associated with novel and significant modifications to ideas, goods, and behaviors. Similarly, learning is characterized by relatively stable changes in comprehension and conduct [9,10,12,13]. It seems reasonable to presume a positive relationship between creativity and academic success, which is viewed as the result of learning.

An earlier study [14] revealed that sixth-graders' creative abilities were more closely related to reading than mathematics. Another German study examining the relationship between student creativity and academic achievement (teacher-determined grades) reached similar conclusions, namely that creativity is most strongly associated with academic achievement in social studies (e.g., history and political science) and less so with academic achievements in language learning (German and English) or mathematics and natural sciences [15,16]. Some researchers [17] discovered positive correlations between students' creativity and academic performance in earth sciences, geography, Spanish, and chemistry.

In addition, the neurocognitive profile of creativity can be studied beyond education and the enhancement of academic performance and within the psychology of individual differences, as it can be related to the parameter of leadership [18–22], clinical psychology, as it can be studied in the context of therapy and psychopathology [23], as well as in special minority groups [24]. All the parameters mentioned above are evaluated in the subsequent.

Moreover, the neurocognitive profile of leadership creativity refers to the underlying brain processes and cognitive mechanisms that contribute to the creative thinking and problem-solving abilities of influential leaders [18,20]. Creativity plays a vital role in enabling leaders to navigate complex challenges, innovate, and inspire others, despite the fact that leadership is a multifaceted concept involving various traits and skills [21,22]. The neurocognitive profile of leadership creativity is comprised of cognitive skills, emotional intelligence, and the capacity to foster a creative and collaborative environment. These

characteristics enable leaders to think critically, adapt to changing conditions, and motivate their teams to produce innovative solutions and superior results. Consequently, creativity is central to effective leadership across a variety of domains and industries.

Another aspect in which creativity is applied in education is gamification. The neurocognitive profile of creativity in gamification refers to the cognitive processes and brain mechanisms engaged when individuals engage in creative activities in the context of gamified experiences. Gamification incorporates game elements and mechanics into non-game contexts to improve user engagement, motivation, decision-making, and overall experience [25]. Gamification can cultivate an environment that encourages innovative thought and problem-solving when combined with creativity [26].

Understanding the neurocognitive aspects of creativity in gamification enables designers and educators to create more engaging and effective gamified experiences that harness the power of creativity to improve learning, problem-solving, and overall user satisfaction [27]. By tapping into the brain's cognitive processes associated with creativity, gamification can become a potent instrument for stimulating innovative thought and fostering an enjoyable learning or interactive environment [28].

Additionally, the neurocognitive profile of creativity in therapy refers to the underlying brain processes and cognitive mechanisms at play when people engage in creative activities as part of the therapeutic process. Clinical psychology frequently employs creative approaches to therapy, which can provide clients with unique advantages and opportunities to investigate and express themselves in novel and imaginative ways. Incorporating creativity into therapy can enhance the therapeutic process by engaging various brain regions and fostering emotional expression, insight, and personal development. Recognizing the diverse ways creativity can contribute to the healing and transformational process, therapists who use creative approaches customize interventions to each client's needs and preferences [29].

While creativity is typically associated with improved academic performance, the relationship between creativity and academic performance in people with psychopathology can be influenced by several factors. It is essential to recognize that despite their difficulties, individuals with psychosis can exhibit remarkable resilience and fortitude. Integrating supportive interventions, cognitive remediation, and creative therapies into academic programs may improve this population's cognitive performance, creative expression, and academic performance.

Due to the complexity of psychosis and its varied effects on individuals, research in this field is constantly evolving. Further research is required to comprehend the neurocognitive mechanisms underlying creativity in people with psychosis and how creative interventions can be effectively integrated into educational settings to enhance academic outcomes. In addition, the treatment and support of individuals with psychosis should be comprehensive, considering their unique strengths, obstacles, and personal objectives [30]. In both correctional facilities and special population settings, it is essential to embrace a holistic approach that recognizes each individual's unique needs and challenges [31]. Trauma, psychological health, and social support are essential to their cognitive and academic abilities [32,33]. Individualized interventions, such as creative therapies, educational programs, and vocational training, can positively affect cognitive abilities, creative expression, and academic performance as a whole [34].

This systematic review aims to investigate whether there is a correlation between creativity and academic capabilities and with which of these capabilities this correlation is usually found. The research sample includes published scientific articles in valid and recognized scientific journals investigating the relationship between creativity and academic skills in different countries and cultures. In addition, the central objective of this paper is to examine and provide answers to the following research questions:

[RQ1] What are the cognitive processes associated with creative thinking?

[RQ2] How does creativity affect academic performance?

[RQ3] What are the differences in the neurocognitive profiles of creative and non-creative students?

[RQ4] How can creativity be fostered in the classroom?

[RQ5] How does creativity interact with other cognitive processes to affect academic performance?

The figure below presents the theoretical framework underlying the current systematic review, wherein academic performance is the central focus. Surrounding this central hub are the key factors that play a crucial role in enhancing academic performance: neuropsychology, education, and creativity. Additionally, these factors are further elaborated upon, highlighting their interconnectedness and interdependence. Neuropsychology focuses on assessing and examining various core components: cognition, emotion, motivation, education through learning, teaching methods and skills, creativity with originality, flexibility, and giftedness. These components are enhanced through specialized training and the utilization of tools specific to the field of neuropsychology. The goal is to foster students' cognitive and psycho-emotional development within an educational setting (Figure 1).



Figure 1. Flowchart of Conceptual Framework.

2. Literature Review

2.1. Neurocognitive Aspects of Creativity in Academic Performance

A neurocognitive framework for human creative thought is proposed by researchers [35]. The authors propose that creative thinking encompasses the dynamic interaction of several cognitive processes, such as associative thinking, divergent thinking, and executive functions. Associative thinking pertains to the cognitive capacity to establish associations between thoughts or ideas that may appear unrelated, facilitating the creation of innovative and unique ideas. Divergent thinking encompasses developing many answers or options, fostering cognitive flexibility, and the ability to produce many ideas. The creative process involves using executive processes, including cognitive control and working memory, to sustain attention, suppress extraneous stimuli, and manipulate mental representations.

Moreover, the significance of predictive representations in creative thinking is underscored by recent research [36]. Predictive representations encompass the cognitive process of building mental simulations or models that enable humans to foresee the likely impli-

cations of their thoughts and subsequently make adjustments based on these anticipated consequences. This technique enables the assessment and enhancement of innovative concepts. In [37], the correlation between cognitive knowledge and creative thinking abilities is investigated, explicitly focusing on the Big Five personality traits. The authors propose that creative thinking is both an outcome and a potential catalyst for developing other cognitive processes, including cognitive thinking. Cognitive thinking encompasses the processes of analysis, evaluation, and synthesis of information, which play a pivotal role in generating and cultivating innovative ideas. In another scholarly work [38], the notion of active imaginative listening, which entails active participation in imaginative and creative cognitive processes during music listening, was explored. This cognitive process enables humans to engage in the exploration of alternate perspectives, the generation of mental imagery, and the establishment of links between various sensory modalities. Engaging in active imaginative listening has the potential to augment creative thinking through the stimulation of the imagination and the facilitation of novel idea development.

In conclusion, another study [39] investigates the impact of creativity and intelligence on academic achievement. The study posits that individuals who demonstrate exceptional abilities in creativity and intelligence tend to attain superior levels of scholastic achievement. This discovery underscores the significance of incorporating creative thinking capabilities alongside cognitive talents inside educational environments to augment academic performance. In brief, the neurocognitive characteristics associated with enhanced academic performance through creativity encompass a range of cognitive processes such as associative thinking, divergent thinking, executive functions, predictive representations, cognitive thinking, active imaginative listening, and the integration of creativity and intelligence. These cognitive processes play a role in the generation of original ideas, the ability to think flexibly, the evaluation and improvement of ideas, and the enhancement of academic achievement.

Several research studies have provided insights into the impact of creativity on academic achievement based on the neuropsychological profile of creativity. In one scholarly work [40], the researchers delved into the nuanced aspects of creativity, shedding light on the potential negative implications. Specifically, they emphasized that individuals with a propensity for unique thinking may be more inclined toward dishonest behavior. Although the cited source did not explicitly examine the correlation between creativity and academic achievement, it posited that creativity might engender adverse outcomes that could indirectly influence one's academic performance. Additionally, one other study [41] investigated the potential causal relationships among processing speed, intellect, creativity, and school success. Their research findings indicated that the speed at which information is processed can directly influence cognitive abilities, such as academic achievement. Additionally, the impact of processing speed on real-world performance may be mediated indirectly through intelligence and creativity. Another study [42] examined the correlations among protracted psychosis phenotypes, socio-emotional adjustment, academic outcomes, and neurocognitive ability. This study primarily examined psychosis phenotypes, but it also offers valuable insights into the potential influence of neurocognitive characteristics on academic ability. These findings could be pertinent to comprehending the relationship between creativity and academic success.

One study [43] investigated the correlation between ethical saliency and deviant behavior among persons with creative inclinations. While this study did not specifically investigate the impact on academic performance, it provides insight into the potential correlation between creativity and deviant conduct, which could have implications for academic achievements. Furthermore, another study [44] examined the impact of virtual reality apps on cognitive load-mediated creativity components and creative performance within the context of engineering design. This study primarily examined the field of engineering design. However, it offered valuable insights into the cognitive processes associated with creativity and their potential influence on creative performance, which could be applicable in academic contexts.

Another study [45] investigated the influence of creativity on functional outcomes among individuals diagnosed with schizophrenia. The primary focus of this study pertains to schizophrenia, although it emphasizes the potential mediating influence of creativity concerning neurocognition and functional results. This implies that the presence of creativity could have a notable impact on academic achievement through its involvement in moderating the connection between cognitive talents and practical results. In another study [46], the intricate relationship between creativity, imagination, personality attributes, and academic success was investigated. Their research findings indicated an indirect relationship between flexibility, conscientiousness, and academic achievement mediated by creativity. This observation underscores the potential impact of creativity on academic performance. The study by [47] examined the correlation between creative thinking and academic achievement, specifically emphasizing English language and mathematics. Their research findings indicated a statistically significant correlation between creativity and academic achievement, wherein higher levels of creativity are linked to improved academic performance. In [37], researchers investigated the correlation between creative thinking capacity, cognitive knowledge, and the Big Five personality traits. Their study's findings indicated variability in creative thinking abilities among students and further revealed that individual personality features influence this variability. This observation underscores the potential impact of creativity on academic achievement, as individual variations influence it.

In [48], the researchers examined the Montessori model and its influence on the development of creativity. Although this citation does not explicitly discuss academic performance, it underscores the significance of educational environments in cultivating creativity, which can potentially impact academic outcomes. In [49], the researchers investigated the cognitive processes involved in students' creative problem-solving, specifically focusing on applying Wallas' theory in the context of mathematical problem-solving. This study primarily examined the field of mathematics, although it offered valuable perspectives on the cognitive mechanisms underlying creative thinking and problem-solving. These insights can potentially apply to academic achievement across other subject areas. The study conducted by [50] explored the correlation between creativity and academic performance, focusing on analyzing potential variations based on gender. The findings of this study indicate a positive correlation between creativity and higher-level accomplishment, particularly in the context of diverse linguistic actions. This observation underscores the potential impact of creativity on academic achievement, particularly in areas related to language and communication. In [39], the author investigated the impact of creativity and intelligence on academic achievement. The study posited that individuals who demonstrate exceptional aptitude in creativity and intelligence are more likely to attain elevated levels of academic achievement. This highlights the significance of incorporating creative thinking talents alongside cognitive ability to augment academic performance.

In summary, drawing from the neurocognitive profile of creativity, it can be inferred that creativity can positively and negatively impact academic achievement. Indirectly, academic success can be influenced by processing speed, IQ, socio-emotional adjustment, and ethical saliency. The potential influence of creativity on the association between cognitive ability and functional results, particularly in connection to academic accomplishment, is a subject of interest. The impact of individual characteristics, namely personality factors, on creative thinking capacity and its correlation with academic performance is noteworthy. The promotion of creativity within educational environments, along with the examination of the cognitive mechanisms behind creative thought, has the potential to enhance academic achievement.

2.2. Neurocognitive Profile Differentiation of Creative and Non-Creative Students

Variations in neuropsychological profiles exist between students classified as creative and those classified as non-creative, encompassing multiple dimensions. According to [51], a suggested relationship exists between creativity and several outcomes, such

as academic success, career potential, and employment performance. This suggests that kids who possess creative abilities may have higher academic accomplishment levels than students who lack creative abilities. The study described in [52] investigated the correlation between creativity and performance in several geometrical problem-solving tasks. The results of their study indicate that students with higher levels of creativity may exhibit superior problem-solving skills and achieve higher performance outcomes when faced with non-routine and open-ended tasks compared to students with lower levels of creativity. The study by Pettersen et al. (2019) examined the progression of creative work engagement among engineering students, focusing on their inclination and proficiency. The findings of their study indicated that children with a higher level of creativity may have a greater inclination and capability to participate in creative endeavors compared to students with lower levels of creativity. A recent study [53] investigated the relationship between perceived creativity and the Big Five personality qualities. The findings of their study suggested that individuals with elevated levels of creativity may manifest distinct personality characteristic profiles compared to others lacking creative tendencies.

In other research, the researchers [54] discussed the values across creative fields. According to their research findings, persons with creative inclinations may exhibit distinct value systems compared to those without creative tendencies, implying potential variations in their neurocognitive profiles. In another study, the researchers [55] examined the variations in creative performance among individuals in the interior design field. The study conducted by the researchers emphasized the possible impact of cognitive styles on creative performance, indicating that individuals with creative abilities may demonstrate distinct cognitive styles compared to those without creative abilities. In a recent study [56], a comparison was made between the viewpoints on creative thinking exhibited by students in art school and those in non-art education. The research indicated that individuals enrolled in art education programs may exhibit distinct neuropsychological profiles compared to their counterparts who are not pursuing art education, implying potential variations in their capacities for creative thinking. Another study [57] investigated the discriminant validity of implicit ideas about intelligence and creativity. The study's findings indicated that individuals with distinct implicit conceptions regarding intelligence and creativity may display varying neurocognitive profiles, suggesting possible distinctions between students who are deemed creative and those who are not.

Another study [58] examined the correlation between sleep patterns, academic success, and performance on neurocognitive tests. The results of the study indicated that there may be variations in sleep quality and neurocognitive function between individuals who possess creative abilities and those who do not, which could potentially impact their academic success. Additionally, in another study, the researchers [48] investigated the Montessori paradigm and its influence on creativity. The findings of their study indicate that students enrolled in Montessori programs may demonstrate elevated levels of creativity compared to students in non-Montessori schools, suggesting potential variations in their neurocognitive profiles. A previous study [46] investigated a complex relationship between creativity, imagination, personality attributes, and academic success. The findings of their research indicated that there may be a correlation between creativity, imagination, and personality qualities, which could have an impact on academic achievement. This shows that there might be variations in the neurocognitive characteristics of individuals who possess creative abilities compared to those who do not.

Another study [59] examined the creativity profiles of students in the development of independent learning activities. The results of their study indicated that students with varying creativity profiles may demonstrate distinct neurocognitive profiles, hence suggesting potential disparities between individuals classified as creative and those classified as non-creative. The study described in [60] examined the utilization of creative cognition and positive affect in academic research. According to their study, it was proposed that kids with a propensity for creativity may demonstrate distinct cognitive and affective mechanisms compared to their non-creative counterparts, potentially impacting their aca-

demic achievements. In the work of another researcher [61], the utilization of creativity to mitigate ethnic bias within the context of college admissions was examined. According to the study's findings, individuals from diverse ethnic backgrounds may demonstrate varying degrees of creativity, implying potential variations in their neurocognitive profiles.

Another researcher [32] investigated the psychological aspects of the inclination towards novelty-seeking, creativity, and innovation. The available evidence indicated that individuals with varying levels of novelty-seeking, creativity, and invention may display distinct neurocognitive profiles, implying possible distinctions between students with creative abilities and those without. Another study [39] focused on examining the impact of creativity and intelligence on academic achievement. The study implied that individuals who thrive in creativity and intellect may exhibit different neurocognitive profiles than those who excel in only one category, highlighting potential disparities between creative and non-creative students. In brief, variations in neurocognitive profiles exist between creative and non-creative students across multiple dimensions. These dimensions encompass problem-solving aptitude, inclination, capacity for creative endeavors, personality characteristics, cognitive approaches, values, sleep quality, and cognitive and affective functioning patterns. The distinctions mentioned above may potentially influence disparities in scholastic achievement among those classified as creative and non-creative students.

2.3. Promotion of Creativity in the Classroom

An increasing scholarly focus is on examining how creativity might be cultivated within educational settings. In another study, the researchers [62] examined a pedagogical framework that effectively leveraged cultural resources to cultivate creative thinking within educational settings. This study offers valuable insights into integrating cultural viewpoints and considerations within teaching techniques, aiming to enhance creativity in the classroom. In another study [63], an examination was undertaken on incorporating creativity within STEAM (Science, Technology, Engineering, Arts, and Mathematics) education. This paper examined the significance of creating an environment that fosters creative thinking and problem-solving within educational settings. In the work of other researchers [32], an examination was conducted on the neurocognitive dimensions related to novelty-seeking, creativity, and innovation. This study offered valuable insights into how comprehending the cognitive processes associated with creativity can enhance teaching methodologies to cultivate creativity within educational settings. A study conducted by other researchers [64] investigated the utilization of neuroscience discoveries in creativity training. This paper examined the implications of comprehending the neurological mechanisms underlying creativity to develop impactful treatments and instructional strategies to cultivate creativity in educational settings. In another study, the researchers [65] investigated the beliefs and actions of teachers concerning their efforts to promote student creativity. This study offers valuable insights into the pivotal role of teachers in establishing a nurturing and intellectually engaging atmosphere that fosters the development of creative thinking and self-expression development. Through the synthesis of the studies mentioned above, it can be deduced that the cultivation of creativity within educational settings necessitates the integration of cultural resources, the provision of opportunities for creative cognition, a comprehension of the neurocognitive dimensions of creativity, the application of neuroscience discoveries to pedagogical approaches, and the alignment of educators' beliefs and practices with the promotion of creativity in students. These strategies facilitate the establishment of a conducive learning environment that fosters and amplifies students' creative thinking abilities and problem-solving aptitudes.

2.4. Creativity and Cognition Interaction

The neurocognitive characteristics associated with creativity are dynamic with other cognitive processes, resulting in diverse impacts on academic achievement. According to research [52], creativity emerges as a notable determinant of students' academic achievement across many categories of geometrical problems, with particular emphasis on open-ended,

non-routine problem-solving tasks. This finding suggests that the relationship between creative thinking and problem-solving skills shapes academic performance in geometry. In one study, the researchers [46] emphasized the interconnectedness of creativity, imagination, personality attributes, and academic success. The study's findings indicated that flexibility exhibits the most significant indirect impact on academic achievement, with conscientiousness, initiating imagination, changing imagination, and extroversion following suit regarding their respective effects. This study examined the relationship between personality qualities and creative thinking concerning their impact on academic results. In another study, the researchers [66] investigated the progression of creative task performance among engineering students. The results indicated that promoting creativity among students has the potential to improve their capacity to participate in and excel at creative endeavors, leading to significant effects on their academic achievements. In another study [67], an examination was undertaken to investigate the correlation between individuals' perceived creativity and the Big Five personality qualities. The study's findings indicated that creativity has a crucial role in problem-solving and cognitive aptitude as adults' vocational and overall life achievements. This finding suggests that variations in individual personality traits can shape how creativity is manifested and its subsequent effects on academic achievement.

In another study [68], the researcher investigated the impact of several interventions on creativity and academic performance. The findings suggest that the utilization of various creative applications can have a beneficial impact on academic performance. The neurocognitive characteristics associated with creativity are reciprocal with several cognitive functions, including problem-solving aptitude, personality traits, and imaginative thinking, thereby impacting academic achievement. Implementing diverse interventions and approaches in the classroom can facilitate the development of creativity among students, augmenting their cognitive processes and yielding favorable outcomes in terms of academic accomplishment.

3. Materials and Methods

This is a systematic review of the literature carried out using the search terms "creativity, intelligence, academic achievement, learning, students, reading, understanding" in bibliographic databases (PubMed, Scopus, and HEAL-link) and their synonyms and combinations.

For an article to be included in the study, it had to meet the following criteria: (1) it had to be a scientific article; (2) it had to be written in English; (3) be germane to the topic of the study; (4) its sample had to include students aged 5 to 16 with normal, typical development; (5) published between 2016 and 2022; (6) published in a reputable scientific journal; (7) the article had to be a research or longitudinal study, (8) be in the field of psychology, (9) be exhaustive; and (10) be freely accessible.

The PICOS (Population, Interventions, Controls, Outcomes, Study design) method was utilized as a criterion for including articles in this study. Articles were included in the search if their country had a population of students up to 16 with standard, typical development and no diagnosed developmental disorders who attended public schools. Children's creativity should have been evaluated using a recognized creativity assessment test, such as the Torrance Creative Thinking Test modified for each country's population, the Dimension Change Card Sort, the Consensual Assessment Technique, or the Aurora battery.

After searching the databases for the articles and implementing the filters, 550 articles were retrieved. After evaluating these, seven articles emerged. After acquiring the bibliography and evaluating the articles based on criteria, duplicate articles were identified and removed from all search results from the three databases. Then, the titles of the articles were evaluated, and those incompatible with the purpose of the systematic review were excluded. The abstracts of the remaining studies were subsequently read, and those that did not satisfy the inclusion criteria were discarded. The full texts of the studies that were

discovered as a result of the previous search were examined, and those that needed to provide the necessary information regarding the subject and purpose of the review were eliminated. The methodology and quality of the studies were evaluated, and those that met the eligibility requirements were chosen (Figure 2).

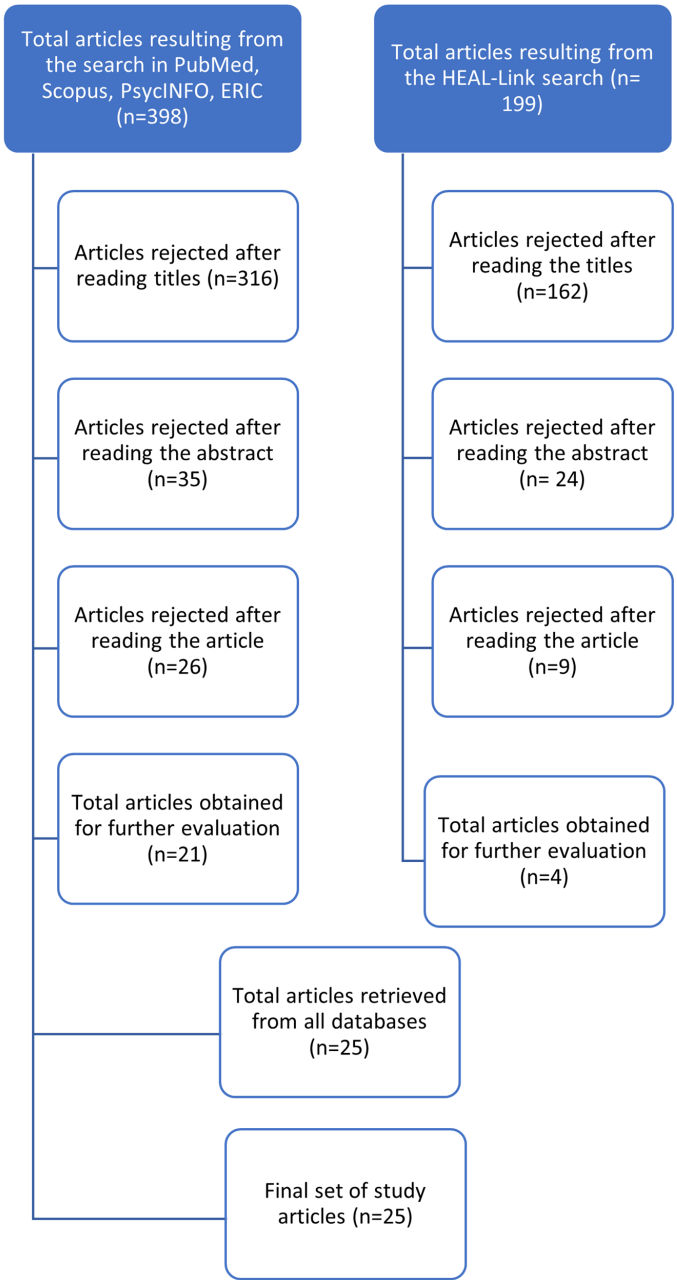


Figure 2. Flowchart of literature review steps.

4. Results

Researchers from various nations and cultural origins published the articles (n = 21). The studies were published in English-language scientific journals. Six research projects were funded—two longitudinal, one cohort, two descriptive, and two explorative studies (Table 1).

Table 1. Main Results and Study Characteristics.

Authors	Population	Purpose	Tools	Results
Bezerra et al., 2022 [69]	75 children (7–9 years old)	Characterizing creativity, intelligence, phonological awareness, and reading decoding and verifying potential relationships between creativity and these skills	Brazilian Figural Creativity Test (TCFI) Wechsler Abbreviated Scale of Intelligence (WASI) Phonological Awareness—Sequential Assessment Tool (CONFIAS) Reading Assessment of Words and Pseudowords Isolated (LPI)	Correlations between creativity with intelligence and reading skills were found for all three grades, with Year 3 having the strongest correlations.
Bayley, 2022 [70]	306 children (7–11 years old)	Exploration of cognitive flexibility based on adaptive skills such as problem-solving and creativity	Dimension Change Card Sort (DCCS) Flexible Item Selection Task (FIST) Object-based Pattern Reasoning Assessment (OPRA)	Cognitive flexibility predicts nonverbal reasoning, and there is limited evidence of a relationship between cognitive flexibility and reading abilities.
Rubenstein et al., 2022 [71]	141 children (5–6 years old)	Examining the relationship between learning and creativity in first graders using static and developmental achievement scores in reading and mathematics	Torrance Tests of Creative Thinking-Figural (TTCT-F) Northwest Evaluation Association-Measure of Academic Progress-Growth (NWEA-MAP-Growth)	Significant positive relationships were found between student creativity and static academic achievement scores in both reading and mathematics.
Sur & Ates, 2022 [72]	380 children (11 years old)	Determining the relationship between reading, listening comprehension and creative thinking levels of 7th grade students	Reading Comprehension Achievement Test Listening Comprehension AchievementTest Torrance Creative Thinking Test Verbal A Form	A positive, statistically significant relationship was found between listening comprehension and reading comprehension scores with creative thinking ability.
Toivainen et al., 2021 [73]	1306 children (9–16 years old)	An investigation of creativity in children's written work at the age of 9 and its association with educational achievement	Consensual Assessment Technique (CAT) WISC-III Cognitive Abilities Test 3	Creative expressiveness, as a measure of creativity, explained variance in English scores independently of children's intelligence and motivation over time.
Zhang et al., 2020 [74]	1082 children (8–15 years old)	Exploring gender differences in the relationship between creativity and academic achievement	Torrance Test of Creative Thinking Figural Form A Self-reported personal data	Creativity and academic achievement and gender differences in which aspects of creativity were related to academic achievement.

Table 1. *Cont.*

Authors	Population	Purpose	Tools	Results
Mourgues et al., 2016 [75]	1165 children (10–16 years old)	Assessing the specific contribution of creativity to future academic performance	Key Stage 2 (KS2) test Aurora General Certificate Secondary education	The general form of creativity was found to contribute to future academic performance independently of other academic skills.
Lamichhane et al., 2020 [76]	Undergraduate and graduate students from engineering, management, and science backgrounds at Kathmandu University, Nepal in Finland and Nepal	Fostering creativity in the classroom is possible through lab-based teaching-learning methods that focus on problem-solving and design thinking. [RQ4]	A lab-based teaching-learning method focused on problem-solving and design thinking was used as an intervention	Results validated the efficacy of lab-based teaching-learning in addressing the need for critical and creative thinking skills among learners.
Bollimbala et al., 2020 [77]	92 MBA students	[RQ4] [RQ2]	A 20-min Hatha yoga intervention session was administered as a short case study	Hatha yoga improves divergent thinking, but the control group worsens it. No effect on convergent thinking. These findings support the executive function hypothesis. The study also finds that encouraging creativity in a routine academic task may not improve it.
Ruiz-Ariza et al., 2017 [78]	184 participants	Creativity Emotional Intelligence (Measured Through 4 Factors: Well-being, Self Control, Emotionality, And Sociability) [RQ4] [RQ3] [RQ2]	A 12-week cooperative high-intensity interval training (C HIIT) intervention	Teens aged 12–16 showed increased creativity and emotional intelligence (EI) with cooperative high-intensity interval training (C-HIIT). Inactive adolescents in the experimental group (EG) improved more in creativity, well-being, and sociability than the control group (CG). Starting PE classes with 16 min of C-HIIT may be recommended, regardless of other activities.

Table 1. *Cont.*

Authors	Population	Purpose	Tools	Results
Nejad, N.S. (2017) [79]	60 participants	Effectiveness Of Children's Educational Model Based On The Criteria Of Creativity [RQ4]	Experimental and Control Groups of preschool children	A clinical trial examined how a child-centered teaching model affected preschoolers' creativity. Results indicated the model significantly impacts children's creativity ($p < 0.05$). This study may affect childhood disorder prevention and treatment
Sadeghi et al., 2020 [80]	30 participants	Mental simulation training can boost architecture students' creativity and academic performance [RQ4]	Teaching mental simulation strategies for 5 sessions of 3 h	Mental stimulation can boost architecture students' creativity and academic performance
Colzato et al., 2018 [81]	80 healthy young volunteers with active tVNS and sham stimulation	Creativity interacts with other cognitive processes to affect academic performance because the vagus nerve is causally involved in creative performance, and GABA (likely to be increased in active tVNS condition) supports the ability to select among competing options in high selection demand (divergent thinking) but not in low selection demand	Transcutaneous vagus nerve stimulation (tVNS) and placebo/sham stimulation	Vagus nerve stimulation (tVNS) boosts divergent thinking. Compared to sham stimulation, active tVNS increased divergent thinking. Results indicated that GABA (likely to be increased in active tVNS condition) aids divergent thinking but not convergent thinking.
Peña et al., 2022 [82]	66 people with 3 characteristics	[RQ5] [RQ1]	20 min of transcranial direct current stimulation (tDCS), transcranial random noise stimulation (tRNS), and sham dose	Divergent and convergent thinking were significantly affected by tDCS and tRNS over the left dorsolateral prefrontal cortex (DLPFC) and left inferior frontal gyrus (IFG). Compared to sham, tRNS performed better in PC fluency and originality. The stimulation groups had no significant effect on cognitive flexibility.

Table 1. *Cont.*

Authors	Population	Purpose	Tools	Results
Bóo et al., 2019 [83]	6 undergraduate students	[RQ3] [RQ2]	A mindfulness intervention was conducted	All students found mindfulness improved self-awareness and self-regulation of thoughts, feelings, and actions. Students' psychological distress and study habits may affect the initial impact of mindfulness on academic performance.
Lifshitz-Ben-Basat, A., and Mashal, N. 2021 [84]	This study was a randomized, double-blind, sham-controlled, crossover study	Transcranial direct current stimulation (tDCS) can alter the left angular gyrus (AG) of the frontotemporal network, motivation traits, and the control network, which are involved in creative thinking. [RQ1]	tDCS (transcranial direct current stimulation) intervention with tDCS (transcranial direct current stimulation) dose	Cathodal tDCS over the left AG significantly increased novel metaphor generation, while anodal stimulation increased conventional metaphors. In the sham condition, higher motivation (behavioral approach system "fun-seeking") was associated with metaphor creativity, while lower fun-seeking was associated with more conventional metaphors. Motivation traits no longer influenced creative metaphor generation after active stimulation.
Akpur, U. 2020 [85]	227 students	Academic Achievement [RQ1]	The Critical Thinking Scale, The Reflective Thinking Scale, and The Marmara Creative Thinking Dispositions Scale were administered	Critical, reflective, and creative thinking were positively and significantly correlated. All three variables significantly predicted academic success.
Peña et al., 2019 [86]	30 people divided into an active tRNS group and a sham group	The Remote Associates Test (RAT), the Torrance Tests of Creative Thinking's Unusual Uses and Picture Completion subtests, and general creativity measure verbal convergent, divergent, and general creativity. No improvement was seen in visual divergent thinking. [RQ1]	A 20-min intervention of transcranial random noise stimulation (tRNS) and sham stimulation	Left tRNS DLPFC improves verbal divergent and convergent thinking. RAT scores, unusual uses fluency and originality, and general creativity differed significantly between the active tRNS and sham groups in mean change scores. No improvement was seen in visual divergent thinking.

Table 1. *Cont.*

Authors	Population	Purpose	Tools	Results
Brown, S. and Kim, E. 2021 [87]	Humans	Creative production is, at least in part, an enhancement of sensorimotor brain areas involved in non-creative production, and the motoric meta-analysis showed that high-level motor areas like the pre-supplementary motor area and inferior frontal gyrus that interface motor planning and executive control were the most concordant. [RQ3]	This study was a meta-analysis	In a meta-analysis of creative production in five domains (verbalizing, music, movement, writing, and drawing), the pre-supplementary motor area and inferior frontal gyrus were activated. The Alternate Uses meta-analysis showed a distinct activation profile, suggesting creative production domain-specificity. Creative production may enhance sensorimotor brain areas involved in non-creative production, according to the activation profiles of the two meta-analyses.
Sunavsky, A. and Poppenk, J.L. 2020 [88]	Humans	In the inferior frontal gyrus (IFG) and inferior parietal lobe (IPL), creative and non-creative students have different neurocognitive profiles, including local grey matter and white matter predictors, the superior longitudinal fasciculus that connects them, and IFG IPL functional connectivity. The anterior lobe of the cerebellum and parahippocampal gyrus predicted creativity across neuroimaging modalities in exploratory analyses. Creativeness was also predicted by basal ganglia white matter integrity. [RQ3]	This study was a pre-registered conceptual replication and extension study	In the inferior frontal gyrus (IFG) and inferior parietal lobe (IPL), local grey matter and white matter predictors in the IFG, the superior longitudinal fasciculus that connects them, and IFG-IPL functional connectivity predicted greater creativity. Creativeness was also predicted by basal ganglia white matter integrity. Experimental analyses showed that the anterior lobe of the cerebellum and the parahippocampal gyrus predict creativity across neuroimaging modalities.

Table 1. *Cont.*

Authors	Population	Purpose	Tools	Results
Saggar et al., 2019 [89]	48 children, 26 children	Creative students have higher externalizing behavior, right lateral frontal segregation, and functional specialization, which tracks creative thinking development. [RQ3]	This study was longitudinal cohort sequential experimental design	Data-driven methods showed that middle childhood creative thinking ability varied, with some children declining and others increasing. These trajectories were linked to developmentally relevant constructs like increased externalizing behavior, not intelligence, age, or sex. Increased right lateral frontal segregation or functional specialization accompanied creative thinking development.
Batey, M. and Hughes, D.J. 2017 [90]	Humans	Cognitive ability measures rarely relate to creative self-perceptions. [RQ3]	This study was a systematic review	Creative self-perceptions rarely correlate with cognitive ability. Openness to Experience and Extraversion positively affect creative self-perceptions. Neuroticism, Agreeableness, and Conscientiousness vary by self-perception, domain, and culture.
Hay et al., 2019 [91]	29 professional engineering designers	Creative and innovative design tasks recruit similar brain regions in professional designers, and creative and non-creative students have greater left cingulate and right superior temporal gyrus activity than a design manipulation control task. [RQ3]	This study was fMRI study	Left cingulate and right superior temporal gyrus activity was linked to creative and innovative design performance. Creative and innovative tasks did not differ in pre-frontal brain activity. Professional designers use similar brain regions for creative and innovative design.
Yang, J. and Zhao, X. 2021 [92]	2355 students from a high school in China	Academic Performance [RQ2]	This study was observational	Creativity boosts academic performance. Convergent thinking affects academic performance more than divergent thinking. Students' self-esteem and internal locus of control affect academic performance through creative thinking.

Table 1. *Cont.*

Authors	Population	Purpose	Tools	Results
Doleck et al., 2017 [93]	104 students	Academic Performance [RQ2]	This study was a structural model employing a partial least squares approach	Except for cooperativity, computational thinking skills did not affect academic performance. Teaching and learning 21st-century skills requires curriculum-mandated higher-order thinking instruction. Successful teaching and learning of 21st-century skills requires curriculum alignment between instructional objectives and evaluation methods.

In all studies, evaluations were conducted on children attending public institutions with the consent of both parents and school personnel. Year of publication, country of origin of researchers, year/duration of implementation, funding, research design, purpose, sample, instruments, results, and conclusions were extracted from each study.

Regardless of children's previous academic performance, Sitorus et al. published a longitudinal study [37] that evaluated the contribution of creativity to future academic performance. The research sample consisted of 1165 seventh-grade students from six schools in England. The researchers used the five "Aurora battery" subtests to evaluate creative and practical abilities to conduct their research. In particular, subtests were administered to evaluate verbal (conversations and figurative language), numeracy (animated numbers), and figurative creativity (book covers and multiple uses). In addition, the Key Stage (KS2) tests were administered to evaluate pupil achievement after completion of certain educational stages.

Furthermore, at age 16, the English, mathematics, and science ratings from the general secondary school certificate were considered. Regarding the procedure, KS2 scores were collected in 2006, the Aurora tests were conducted two years later in 2008, and the scores were examined in conjunction with GCSE scores four years later in 2012. Multiple (domain-specific) creativity factors represented the Aurora subtest scores less accurately than a single (general) creativity factor. Thus, it was determined that the subtests assessed a standard set of general creativity skills but independently evaluated a distinct set of creative skills. In addition, creativity could be used to predict GCE scores independently of KS2 scores. According to the researchers, this result was based on the fact that the creative skills assessed by Aurora are distinct from the academic skills measured by KS2 and may have contributed more to the long-term prediction of GCSE performance four years later. Independent of other academic abilities, the researchers discovered that a general form of creativity contributes to future academic performance.

In 2020, researchers [41] examined the relationship between creativity and academic achievement, as well as gender differences in this relationship, among Beijing, China's upper primary school students. Children aged 8 to 15 years old in Beijing, i.e., fourth, fifth, and sixth-graders from four primary public institutions, participated in the survey. Children's creativity was evaluated using the Chinese variant of the Torrance Test of Creative Thinking (TTCT). In addition, the researchers created a survey to capture the students' personal information. The students' academic achievement was determined by their final semester grades, which professors or a faculty commission evaluated. The correlation between

student creativity and academic achievement was found to range from weak to moderate in the study's findings. The five creativity subtest scores (originality, fluency, elaboration, abstract titles, and resistance to premature closure) were significantly and positively related to students' Chinese performance, whereas only four of the subtest scores (fluency, originality, resistance to premature closure, and abstract titles) were significantly related to students' mathematics achievement. In addition, boys and girls performed notably differently on assessments of creativity. Specifically, boys outperformed girls in originality, whereas girls outperformed boys in abstract title usage. Furthermore, processing and using abstract title scores were considerably correlated with girls' Chinese and mathematics academic achievement.

In contrast, for boys, resistance to early closure was associated with their academic performance in Chinese and mathematics. In contrast, originality and use of abstract titles were only associated with their academic performance in Chinese. The researchers concluded that students' creativity was significantly and positively correlated with their academic achievement and that females' creativity tended to be adaptive. Simultaneously, males demonstrated both innovative and adaptive creativity.

Other researchers [40] conducted a longitudinal study to examine the relationship between nine-year-old children's creativity and educational achievement, regardless of the student's intellect or motivation. The sample consisted of 1306 twin children from Welsh and English institutions. The inclusion criterion for the study was data from children's written accounts between the ages of nine and sixteen. The Consensual Assessment Technique (CAT) was used to code the creativity and nine other dimensions of nine-year-old children's home-written stories under the supervision of their parents and guardians. The CAT measures creativity in shared creative products like children's written stories. On a seven-point scale with ten criteria, children's stories were evaluated: creativity, likeability, novelty, imagination, logic, emotion, grammar, detail, vocabulary, and straightforwardness. Verbal and non-verbal tests were used to assess intelligence at age nine, such as the Vocabulary and General Knowledge tests from the WISC-III and the Figure Classification and Shapes tests from the Cognitive Abilities Test 3. The motivation to write at age nine was assessed with two questions to parents/guardians and children. Teachers assessed educational attainment at ages nine and twelve by recording current achievement in grammar, spelling, and writing, and educational attainment at ages nine and thirteen was assessed by teachers by recording current achievement. According to the research, creative expression and writing motivation at age nine were not significant predictors of academic achievement.

In contrast, logic, intellect, and ninth-grade English writing grade were significant predictors for all children. However, in the second half of the sample, the finding that logic at age 9 is a statistically significant predictor of English writing at age 12 was not replicated. In addition, creative expressiveness, as a measure of creativity, explained variance in English scores across time independent of children's intellect and motivation. In addition, the study revealed moderate genetic and environmental influences on writing creativity at age nine. This study also revealed some intriguing gender distinctions. At nine, females scored higher than boys on tests of creative expression and reasoning, writing motivation, and English writing grades. Even in adolescence, the researchers concluded that creativity in children's writing is associated with academic achievement.

In a 2022 descriptive study, researchers [39] examined the relationship between creative thinking and Turkish students' reading and listening comprehension levels, thereby attempting to demonstrate a connection between language and thought. The research sample comprised 380 seventh-graders from eight public schools in the Iconium Province of Turkey. The only baseline for the study was the seventh grade because the researchers wanted to examine the development of abstract processing and creative thinking abilities, which develop by age 11. Students' reading comprehension skills were evaluated with the Reading Comprehension Achievement Test (RCAT), their auditory comprehension skills with the Auditory Comprehension Achievement Test (LCAT), and their creative thinking with the Torrance Tests of Creative Thinking (TTCT). Pearson correlation analysis was

utilized for the data analysis. The survey results indicated that secondary school students' reading and listening comprehension levels are average. The correlation between reading comprehension and auditory comprehension was statistically significant, while the correlation between reading comprehension and fluency, a subdimension of creativity, was the least significant. In addition, there was a positive and statistically significant correlation between listening comprehension and creative thinking scores. There was also a positive and significant correlation between reading and auditory comprehension. Finally, a correlation between reading comprehension and creative thinking abilities appeared. All association trends were statistically significant, according to the researchers' findings. Therefore, they believe it necessary to encourage students to develop a positive attitude toward reading, listening, and writing and exercise reading and writing to foster and develop their creative thinking.

In 2022, other researchers [38] studied the relationship between first-grade students in the Midwestern United States and their creativity. The survey included 141 students, with a mean age of 6.19 years, from two schools with comparable demographic characteristics in the Midwestern United States. The research was conducted using the Torrance Tests of Creative Thinking-Figurative (TTCT-F) to measure the students' creativity and the Northwest Evaluation Association-Measure of Academic Progress-development (NWEA-MAP-Growth) to evaluate students' achievement development in math and reading over time. To conduct the research, permission was sought from the student's parents, who were notified via electronic newsletter and regular mail and gave their assent. The research revealed a correlation between all TTCT-F scores and academic achievement, including math and literacy. This suggests that even kindergarten and first-grade students exhibit the exact relationships between creativity and academic achievement as older students. In addition, students who can better comprehend stimuli or generate original ideas are more likely to demonstrate academic success. However, no significant correlations between academic development and TTCT-F scores were discovered. However, grade level substantially influenced the relationship between creative thinking processes and academic growth in reading and mathematics, with kindergarteners exhibiting significantly more significant growth than first graders. Inferred from the foregoing, the study demonstrates significant positive relationships between TTCT-F performance and static academic achievement scores in reading and mathematics. However, the correlation with academic growth scores could have been more precise.

In 2022, researchers [35] conducted a cohort study with measurements in grades one and four on cognitive flexibility based on adaptive skills, such as problem-solving and creativity, in low-resource school-attending Rwandan students. Three hundred and six children aged 7–8 and 10–11 from primary institutions in Kigali, Rwanda, as well as informal settlements and villages, participated in the study to determine the population's poverty index. The Dimension Change Card Sort (DCCS), which assesses the classification of primarily colors and shapes, and the Flexible Item Selection Task (FIST), which measures flexibility in selection and object matching, were used to evaluate children's cognitive flexibility. The Object-based Pattern Reasoning Assessment (OPRA), which assesses non-verbal reasoning through the recognition of patterns in sequences, four literacy activities were used to assess reading, which was selected from validated context-adapted reading assessment tools and in the Rwandan language, and self-made questionnaires were used to assess the student's personal and socioeconomic characteristics. Several factors demonstrated significant correlations with students' cognitive flexibility, as demonstrated by the research findings. In measures of cognitive flexibility, literacy, and nonverbal reasoning, Grade 4 students scored substantially higher than grade one students. This was true for both literacy and nonverbal reasoning assessments.

Even after controlling for background variables, significant differences were found in the cognitive flexibility of Rwandan students across schools. In addition, the family structure appeared to significantly affect cognitive flexibility, as children from single-parent families performed better than students from nuclear families despite living in more

modest homes and consuming fewer protein-rich foods. The most significant finding of this study is the correlation between cognitive flexibility and other learning outcomes among Rwandan children, as cognitive flexibility predicts non-verbal reasoning. In addition, limited evidence of a correlation between cognitive flexibility was discovered. Due to their limited exposure to print and written materials before entering the classroom, seven- and eight-year-olds need help with adaptability and literacy skills. The correlations between cognitive flexibility and reading and language skills appeared more stable and dependable among fourth-graders. The researcher concludes that curricula based on fostering abilities that enhance creativity and problem-solving are the foundation for enhancing academic accomplishments and developing skills to adapt to changing conditions.

Additionally, researchers [36] conducted an exploratory study on the relationship between creativity and reading, phonological awareness, and decoding skills. The sample consisted of 75 children of both sexes in grades one (6–7 years), two (7–8 years), and three (8–9 years) from public elementary institutions in Natal, Brazil. The method's selection criteria required candidates to be in grades one to three at a primary school in Natal. In contrast, exclusion criteria included a history or diagnosis of neurodevelopmental disorder and hearing, vision, and movement disorders. The Brazilian Figural Creativity Test (TCFI), which measures creativity through numbers, was used to evaluate the abovementioned abilities. The Wechsler Abbreviated Scale of Intelligence (WASI), adapted for the Brazilian territory, the Phonological Awareness—Sequential Assessment Tool (CONFIAS), which measures phonological awareness, and the Reading Assessment of Words and Pseudowords Isolated (LPI), which measures children's reading of words and pseudowords. All parents and guardians were informed and provided written consent for their children's participation. The children were withdrawn individually from the classroom for three 40 min assessment sessions in a room with minimal distractions. The results indicated that creativity did not appear to develop, as expected by the researchers based on the available literature, and that there were no significant differences between school years. No significant distinctions existed between the first and second grades regarding phonological awareness performance. On the LPI, all divisions had relatively low performance. However, their performance improved as the number of students in a class increased. Furthermore, significant all-grade correlations were found between verbal tests, executive functions (intelligence assessment), and creativity, and these correlations increased over time, even when intelligence and creativity indices were below average.

Regarding the relationship between creativity, reading, and phonological awareness, it was observed that correlations between creativity, phonological awareness, and reader decoding were weak regarding significance and effect size in the first and second years. In contrast, the correlations in the third year ranged from moderate to robust. These disparities are likely the result of the first- and second-graders immature development. It was discovered that creativity in reading allowed for the development of cognitive skills, including language, imagination, freedom of expression, and cognitive and linguistic abilities. The researchers determined that creativity was related to skills such as literacy and intelligence in all three grades, with the strongest correlations occurring in third grade.

5. Discussion

Creative thinking is linked to various cognitive processes. According to a study [81], it was discovered that transcutaneous vagus nerve stimulation (tVNS) can promote divergent thinking, which refers to the cognitive skill of generating various solutions to a given problem. The study conducted by Peña in 2022 demonstrated that the application of transcranial random noise stimulation (tRNS) on the left dorsolateral prefrontal cortex (DLPFC) resulted in enhanced performance on a picture completion test. This task is commonly used to assess fluency and originality in divergent thinking. The study conducted by a researcher in 2021 [84] revealed that the application of cathodal transcranial direct current stimulation (tDCS) on the left angular gyrus (AG) enhanced the production of unique metaphors. Conversely, anodal tDCS was found to facilitate the formation of traditional

metaphors. In another study [86], it was determined that transcranial random noise stimulation (tRNS) administered over the left dorsolateral prefrontal cortex (DLPFC) yielded enhancements in verbal convergent and divergent thinking abilities. The studies mentioned above suggest that creative thinking encompasses various cognitive mechanisms, namely divergent thinking, cognitive flexibility, and metaphor formation. Furthermore, these cognitive processes can be influenced by the application of brain stimulation techniques such as transcutaneous vagus nerve stimulation (tVNS), transcranial random noise stimulation (tRNS), and transcranial direct current stimulation (tDCS) [RQ1].

Moreover, implementing physical and mental activities, such as Hatha yoga and cooperative high-intensity interval training, can enhance students' creativity. The study conducted by a researcher in 2020 [77] revealed that engaging in a 20 min Hatha yoga session significantly enhanced divergent thinking abilities among MBA students. In a study conducted by another researcher in 2017 [78], it was discovered that the implementation of cooperative high-intensity interval training positively impacted the enhancement of creativity and emotional intelligence among a group of physically unfit adolescents. However, the study conducted by a researcher in 2020 [83] yielded varied outcomes regarding the influence of mindfulness on academic achievement. Some students indicated a good correlation between mindfulness and academic performance, whereas others claimed an initial negative association. In general, the literature indicates that engaging in physical and mental workouts can enhance creativity and, conceivably, scholastic achievement. Further investigation is required in order to gain a comprehensive understanding of the interplay between these variables [RQ2].

Concerning the differentiation of neurocognitive abilities between pupils classified as creative and non-creative pupils, notable distinctions exist in the neurocognitive profiles exhibited by individuals falling into these categories. In one study [94], it was observed that individuals recognized as prominent creators exhibited discernible activity patterns in brain regions associated with default mode and executive functioning when engaged in creative thinking, as opposed to individuals not recognized as eminent thinkers. In another study [95], it was observed that individuals with high levels of creative achievement exhibited discernible structural variations in their brains, particularly within the parietal cortex, compared to individuals with average levels of creative achievement.

According to one researcher [74], the cognitive process of creativity encompasses both divergent and convergent thinking, which are influenced by metacontrol states that may be observed through distinct patterns of cortical brain activation. In general, the publications mentioned above indicated variations in brain activity patterns and brain morphometry that are linked to creative performance. Furthermore, these variations may correlate with an individual's creative eminence or accomplishment level.

Furthermore, one study [96] revealed that engaging in creative production positively impacts the sensorimotor brain regions that are often associated with non-creative production. According to another study [89], it was observed that enhanced levels of creativity were generally associated with specific characteristics of the inferior frontal gyrus (IFG) and inferior parietal lobe (IPL). These characteristics encompassed local grey matter and white matter predictors within the IFG, the superior longitudinal fasciculus that connects these regions, and the functional connectivity between the IFG and IPL. According to the study [97], there were identifiable patterns in the development of children's creative thinking ability during middle childhood. The research also revealed that enhanced segregation or functional specialization in the right lateral frontal region of the brain corresponded with increases in creative thinking capacity over time. In a study conducted by a researcher in 2017 [90], it was discovered that a consistent and positive correlation exists between individuals' self-perceptions of creativity and their levels of Openness to Experience and Extraversion. Nevertheless, the associations between Neuroticism, Agreeableness, and Conscientiousness exhibit a greater level of complexity and differ depending on the specific form of self-perception (such as trait, process, or product), the particular domain of self-perception (such as arts or science), or the cultural context [RQ3].

Moreover, the cultivation of creativity within the educational setting can be facilitated by a range of interventions. According to another study [76], the implementation of laboratory-based learning had a positive impact on the enhancement of critical thinking and creativity among both undergraduate and graduate students. The study [77] revealed that engaging in a 20 min Hatha yoga session enhanced divergent thinking abilities among MBA students. In a study conducted by Ruiz-Ariza in 2017, it was discovered that implementing cooperative high-intensity interval training yielded positive effects on physically inactive adolescents' creative abilities and emotional intelligence. In the study [79], it was determined that implementing a child-centered teaching model, which was designed according to specific creativity criteria, significantly enhanced preschool children's creative abilities. The results of this study indicated that many interventions, including laboratory-based learning, Hatha yoga, cooperative high-intensity interval training, and child-centered teaching approaches, can enhance creativity in the classroom [RQ4].

Moreover, the interplay between creative and cognitive processes influences academic achievement. In a study [81], it was discovered that the application of transcutaneous vagus nerve stimulation (tVNS) improved divergent thinking, a crucial aspect of creativity. The study [82] demonstrated that applying transcranial random noise stimulation (tRNS) on the left dorsolateral prefrontal cortex and left inferior frontal gyrus enhanced performance on a picture completion test. This task is commonly used as an indicator of divergent thinking abilities. Nevertheless, the study conducted by Peña in 2022 did not yield any statistically significant results about the impact on convergent thinking or cognitive flexibility. The results of this study indicated that the augmentation of creativity through activating targeted cerebral areas could potentially lead to an enhancement in scholastic achievement [RQ5].

Additionally, this research presents empirical support for the correlation between creativity and performance. Based on the empirical findings of the conducted research, it was observed that creativity significantly impacted academic achievement, irrespective of other academic abilities. Furthermore, research findings have indicated that cultivating adaptive creativity positively influences the academic performance of females. Conversely, both inventive and adaptive creativity have been identified as significant contributors to academic success for males. The presence of creativity can be observed in children's written work, and it can be considered an indicator of their potential for achieving scholastic achievement in the future. Ultimately, a significant association has been shown between individuals' reading and listening abilities and their creativity and mathematical proficiency levels.

Specifically, this study offers many insights into the correlations between creative cognitive processes and achievement in academic settings. Nevertheless, numerous constraints will exert an influence on future research endeavors. The research investigations may have benefited from a larger sample size, which would have allowed for more generalizability of the results to a diverse population of students from other nations. Furthermore, much research has indicated a moderate association between creativity and educational attainment—the evaluation process needed to comprehensively assess diverse academic disciplines and competencies. The scope of the research articles, however, was constrained to particular skills associated with creativity, including reading, writing, and mathematics.

Based on the constraints mentioned above, it is advisable to undertake further investigation to assess the impact of creativity on improving abilities within an educational setting. The necessity of conducting systematic reviews is widely acknowledged, wherein the inclusion of research incorporating additional variables, such as children's personality traits, the socio-economic setting of their development, and the characteristics of their families, is deemed essential for investigating this association. Furthermore, it is recommended that future studies aim to comprehensively understand the role of creativity in the learning process, considering many aspects at the classroom level. Ultimately, examining the potential ramifications of a lack of creativity within educational settings on scholastic achievement is imperative.

The impact of creativity on future academic performance is both predictive and cumulative. Hence, it is imperative to acknowledge and foster creativity within education

while facilitating avenues for the manifestation and cultivation of creative abilities. This, in turn, can engender novel prospects for educational and vocational growth among students.

The concept of creativity is a complex and multidimensional construct that has had a profound influence on scholastic achievement. Numerous scholarly investigations have examined the correlation between creativity and academic attainment, focusing on elucidating the neurocognitive aspects of creativity and its impact on bolstering scholastic accomplishment. Another study [46] discovered that creativity can serve as a compensatory mechanism for those with lower levels of intellect, positively influencing their academic achievement. The researchers concluded that a statistically significant positive relationship exists between creativity and academic accomplishment. Furthermore, they found that higher levels of creativity among students are associated with increased academic achievement. A further investigation [47] provided evidence of the correlation between creativity and academic performance. The study revealed a statistically significant correlation between creativity and academic performance, as evidenced by a confidence level of 99 percent.

Additionally, some researchers [96] conducted a study in which they formulated a theoretical framework suggesting that self-perceived intelligence and creativity, in conjunction with the Big Five personality traits, are predictors of psychometric intelligence and creativity. These factors, in turn, are posited to influence academic achievement. The investigation of creativity from a neuroscientific perspective has provided valuable insights into the neurocognitive mechanisms that underlie creative thinking and its influence on academic achievement. According to [36], neuroscientific research on creativity is currently lacking in theoretical development. Nevertheless, it exhibits potential for elucidating the brain systems implicated in creative cognition. In conjunction with the neurocognitive characteristics associated with creativity, there are additional elements, namely personality traits and emotional intelligence, which have been observed to impact one's scholastic achievements. According to [89], a positive correlation exists between self-reported conscientiousness and academic success. Nevertheless, when conducting cross-country evaluations, it has been observed that nations exhibiting higher levels of conscientiousness tend to exhibit poorer performance on assessments measuring mathematical and reading abilities.

Furthermore, another study [98] revealed that emotional intelligence, in conjunction with creativity, exerts a noteworthy influence on academic achievement among youngsters. This implies that the interplay between cognitive and emotional elements plays a role in determining academic success. The correlation between creativity and academic achievement is a topic that has generated considerable debate. In the scholarly discourse, a study [97] draws attention to divergent findings in the existing literature concerning the correlation between creativity and academic attainment. Nevertheless, most of the studies examined in this study substantiate the existence of a favorable correlation between creativity and academic performance.

In summary, the neurocognitive characteristics associated with creativity have a significant impact on improving academic achievement. The presence of creativity can serve as a means to offset a deficiency in intellectual capacity and augment one's academic performance. Examining creativity from a neuroscientific perspective provides valuable insights into the neurological processes underlying innovative and imaginative ideas. Various elements, such as personality traits and emotional intelligence, are known to exert influence on academic achievement. In educational environments, the cultivation of creativity can have beneficial outcomes for students' academic performance.

6. Conclusions

The neurocognitive profile of creativity influences academic performance positively through multiple cognitive, emotional, and motivational mechanisms. Integrating creative approaches into educational practices may improve students' problem-solving skills, motivation, and engagement and reduce their stress levels. However, the precise nature of these effects may vary based on the situation and the individual. As neuroscience and education

continue to develop, additional research is required to understand the relationship between creativity and academic achievement.

The results of this research illustrate a significant and positive correlation between creativity and educational competence, specifically in the domains of reading, comprehension, and written assignments. Neurocognitive processes, such as predictive representations, executive functions, associative and divergent thinking, and predictive thinking, significantly influence the attributes associated with creativity. The study advocates for enhancing creativity in academic environments by examining the correlation between the utilization of cultural resources, the congruence between instructors' attitudes and the encouragement of creativity, and the understanding of neurocognitive factors that impact creative processes.

Although creativity has the potential to affect academic performance positively, it is crucial to acknowledge and analyze the limitations and potential confounding factors that could influence the neurocognitive aspects of creativity concerning its impact on academic performance. Various factors, including neurocognitive deficits, sleep patterns, emotional parameters (anxiety), gender differences, individual traits, and educational attainment, can significantly influence the association between creativity and academic achievement [99]. To overcome these limitations, it is imperative to adopt a multidisciplinary approach that integrates perspectives from various disciplines such as neuroscience, psychology, education, and related fields.

Further research into the neurocognitive aspects of creativity concerning enhancing academic performance may delve into diverse avenues, thereby expanding our comprehension of this association. An area that warrants exploration is examining the influence of social media on academic achievement and creative abilities. In addition, future longitudinal studies have the potential to offer further insights into the predictive capacity of neurocognition and its influence on academic achievement. Further exploration is warranted in examining the role of creativity within the realm of academic entrepreneurship. Furthermore, researching the correlation between emotional intelligence and creative performance can yield significant insights. Subsequent research endeavors may delve into the examination of the influence exerted by emotional intelligence on the creative output of individuals, thereby elucidating its potential ramifications on scholastic attainment. Moreover, it is suggested that future studies investigate the correlation between curiosity, creativity, and motivation concerning academic achievement. Furthermore, future research endeavors may delve into the examination of various components of the educational setting, such as pedagogical approaches and physical classroom arrangements, in order to ascertain their effects on the cultivation of creativity and its subsequent implications for scholastic achievement.

Lastly, Virtual Reality (VR) and Augmented Reality (AR), along with the utilization of Artificial Intelligence (AI) algorithms and recommender systems mainly applied in education, health, or other research fields, have the potential to analyze and comprehend patterns in creative thinking [100]. This analysis can illuminate the correlation between creative thinking and academic achievements. Furthermore, investigating the impact of immersive creative experiences on brain function represents another significant avenue for future research.

Moreover, future investigations about the role of creativity in educational environments could explore the inclusion of special populations, such as gifted individuals, by analyzing their neurocognitive profile. Researching the examination of creativity within populations characterized by attention deficit hyperactivity disorder (ADHD), autism, dyslexia, and other neurodivergent conditions holds significant potential for advancing scholarly investigations in this domain. With the progression of technology and the increasing knowledge about the brain, there is a growing potential to explore the neurocognitive characteristics of creativity and its impact on academic achievement. The findings of this study have the potential to significantly influence educational methodologies, pedagogical strategies, and societal perspectives regarding creativity and intelligence.

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