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Effects of Digital Technology Interventions on Creativity in Childhood and Adolescence: An Umbrella Review

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Abstract

Objective: This umbrella review aimed to integrate the findings on the effects of digital technology interventions on creativity across childhood and adolescence, with a focus on the direction, magnitude, and consistency of findings within technology families, developmental patterns, outcome and measurement specificity, and intervention design and setting. This study provides an integrated account of which digital technology interventions appear beneficial for specific creativity outcomes, developmental stages, and implementation conditions.

Method: Scopus, ERIC, and Web of Science were searched from inception to August 2026 without search filters. Additionally, Google Scholar was searched as a supplementary source. Eligible reports were systematic reviews or meta-analyses with separable evidence for participants aged 0-18, an active digital component, and an explicit creativity outcome.

Results: 15 reviews, including 10 meta-analyses and five systematic reviews, were included. Digital interventions generally showed positive effects across technology families, although heterogeneity prevented a reliable ranking. Developmental patterns were inconsistent, and the evidence mainly focused on divergent-thinking outcomes. More favorable findings were generally reported for active and structured technology use; duration patterns differed across technologies and outcomes, while the only direct setting comparison, reported for educational robotics, favored classroom implementation.

Discussion: Digital technologies can support creativity in children and adolescents, but their effectiveness appears to depend on developmental fit, the targeted creativity outcome, and

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implementation conditions rather than the technology alone. These findings can guide the design of age-appropriate and outcome-specific interventions, while future studies should examine duration and setting more consistently.

Keywords*:* Creativity, Child, Adolescent, Digital Technology, Umbrella Review.

1. Introduction

Creativity has been recognized as an essential and valuable skill in the twenty-first century (Hendriyani et al., 2022; Rawlings et al., 2025; Thornhill-Miller et al., 2023), and its most accepted definition is the ability to produce ideas or products that are both novel and useful (Harvey & Berry, 2023; Yeo et al., 2024). The United Nations has also identified creativity as a key skill for addressing sustainable development challenges (Sio & Lortie-Forgues, 2024). Studies have shown that creativity is a complex cognitive ability, which depends on higher-order thinking and is associated with multiple cognitive mechanisms, including cognitive flexibility, inhibitory control, and working memory (Green et al., 2024; Paz-Baruch & Maor, 2023).

The importance of creativity for children and adolescents is particularly notable. Childhood and adolescence are developmental periods that, because of the high degree of brain plasticity during these years, represent an important window for fostering creativity (Larsen & Luna, 2018). Creativity during childhood and adolescence is associated with a wide range of benefits, including greater emotional well-being and higher resilience, and predicts creativity in adulthood (Alves-Oliveira et al., 2022; Li et al., 2025). Moreover, enhancing creativity is now considered essential for achieving effective and efficient learning (Larraz, 2021). Therefore, educational systems in countries such as Finland, Australia, Singapore, and Canada emphasize the inclusion of creativity-related courses in their educational programs (Cramman et al., 2020).

Given these considerations, efforts to design and assess programs capable of enhancing creativity have received increasing attention in the present century. Unlike in the past, when creativity was regarded as fixed and innate, it is now commonly understood as neither limited to intelligence nor an unchangeable construct, but rather as a flexible and modifiable ability (Benedek et al., 2021) that depends on cognitive development, learning, and practice in an area of interest (Lilly, 2019).

At the same time, one of the issues of interest in improving creativity is examining the use of technology and how it can contribute to creativity-enhancement programs. Alongside creativity, technology has become a vital element in education and learning (Fielding & Murcia, 2022). In fact, one important method of delivering educational content that has recently received considerable attention is technology-based instruction. In technology-based instruction, various digital technologies are used to deliver educational content and facilitate learning (Sitorus et al., 2025). Today, it is difficult to imagine education and technology separately, and technology-based instruction is currently considered part of routine educational and learning practices (Gu et al., 2024; Mejia et al., 2021).

Digital technology in education can be understood as the use of digital tools or methods to facilitate content delivery and improve learning (Timotheou et al., 2023). Therefore, a variety of digital technologies can be used in education, including video-based instruction, computer games, educational software, web-based platforms, educational robotics, artificial intelligence, and virtual or augmented reality (Li et al., 2022; Peng et al., 2025; Xiong et al., 2025; Zhang & Zhu, 2024). These technologies can be used online or offline and across different educational settings and modes of teaching. Technology-based instruction is therefore broader than electronic or web-based learning, which represent only some of its possible forms. From a cognitive perspective, digital interventions are relevant not only as delivery tools but also because they can structure the activities through which learners generate, explore, revise, and evaluate ideas. Their effects on creativity may therefore depend not only on the technology itself, but also on the cognitive demands and pedagogical design of its use (Fielding & Murcia, 2022; Li et al., 2022).

Although creativity has become a priority for governments, educational institutions, and other organizations, and has been linked to economic, social, political, scientific, and health-related development (Eyre et al., 2022; Eyre et al., 2021; Smith et al., 2021), identifying an appropriate method for improving it within educational systems remains challenging. While there is general agreement that students need to be creative, the development of creative thinking skills through formal education still requires greater attention (Karunarathne & Calma, 2024; Larraz, 2021). Few curricula devote sufficient time and attention to developing these skills, and many educational systems may also restrict students' creativity.

Against this background, the increasing popularity of technology-based learning platforms has further highlighted the importance of examining how educational programs are delivered. Previous studies and reviews have addressed different aspects of technology-based interventions for improving creativity, but only a limited number have focused specifically on the tools used to deliver the intended instruction and exercises (Alves-Oliveira et al., 2022). Moreover, previous research has emphasized the need to design technology-based instruction for improving creativity (Aguilar & Pifarre Turmo, 2019), but how these tools can be used effectively remains unclear (Henriksen et al., 2021; Yalcinalp & Avci, 2019). Therefore, examining how technology can effectively enhance creativity remains an important area of research (Tang et al., 2022).

However, the question is not limited to whether digital technologies improve creativity. Existing reviews have generally focused on a particular technology family or examined a broad range of tools using different age groups, creativity constructs, effect metrics, and analytical approaches (Li et al., 2022; Peng et al., 2025; Xiong et al., 2025). Their conclusions are therefore difficult to compare directly, and it remains unclear whether the direction of findings is consistent across technology families or whether the magnitudes reported within reviews show similar patterns. Developmental interpretation is also limited because children and adolescents have sometimes been examined alongside university students, while age-specific findings are often based on a limited number of studies or reported using different educational-stage categories (Fielding & Murcia, 2022; Peng et al., 2025; Wang et al., 2024). At the same time, creativity has been represented through divergent-thinking components, creative performance and products, self-reported characteristics, and other outcomes measured with non-equivalent instruments (Li et al., 2022; Peng et al., 2025). Consequently, a positive finding for one outcome cannot necessarily be generalized to creativity as a whole.

The effectiveness of digital technologies may also depend on more than the technology itself. The active role assigned to learners, the pedagogical design of the activity, the provision of feedback and guidance, the duration of the intervention, and the setting in which the technology is used may all influence the reported outcomes. However, these conditions have not been examined or reported consistently across reviews. This limitation is particularly important during childhood and adolescence, when interventions need to correspond with developing cognitive abilities and the educational environments in which learning occurs.

Accordingly, the present umbrella review was conducted to integrate and compare the findings of systematic reviews and meta-analyses on the effects of digital technology interventions on creativity across childhood and adolescence. The review therefore addresses four research questions:

RQ1. What direction of effects are reported within each digital technology family, and how consistent are the findings across reviews?

RQ2. What developmental patterns are evident across childhood and adolescence, and do the reported effects differ according to age or educational stage?

RQ3. Which aspects of creativity have been examined, how have they been measured, and how do the findings vary according to the outcome and measurement approach used?

RQ4. What evidence is available on the relationships of intervention design, implementation, duration, and setting with the reported creativity outcomes?

By addressing these questions, this review moves beyond asking whether technology improves creativity and instead clarifies where the evidence appears more favorable, for whom, which aspect of creativity, and under what conditions. Its main contribution is to provide an integrated review-level map of the current evidence and locate the developmental, measurement, and implementation gaps that should guide future research. The findings may also help educators and intervention designers select developmentally appropriate technologies and match digital activities to the intended creativity outcomes, and design programs that use technology as meaningful support for creative cognition rather than assuming that the presence of technology alone is sufficient. More broadly, the review can help connect research on digital learning with research on the development and measurement of creative cognition.

2. Method

2.1. Research objectives and design

This study was conducted as an umbrella review of systematic reviews and meta-analyses to synthesize outcome-specific evidence on digital technology interventions designed to support creativity across childhood and adolescence. The review questions, eligibility criteria, extraction domains, and synthesis rules were specified in an internal working protocol before final data synthesis. Reporting was informed by PRISMA 2020 and PRISMA-S (Page et al., 2021; Rethlefsen et al., 2021). The unit of inclusion was the review, while extraction was restricted to evidence directly relevant to participants aged 0-18 years, preschool learners, or K-12 students.

2.2. Eligibility criteria

Reports were eligible when they were: (a) systematic reviews, systematic literature reviews, meta-analyses, umbrella reviews, or another review with explicit systematic search and selection methods; (b) included children or adolescents aged 0-18 years, preschool or K-12 learners, or mixed populations with separately extractable findings for these groups; (c) examined a digital technology as a central and active component of an intervention, instructional design, or creative-learning environment intended to foster, practice, support, or improve creativity; and (d) reported or synthesized at least one explicit creativity outcome, including creativity, creative thinking, divergent or convergent thinking, originality, fluency, flexibility, elaboration, novelty, usefulness or appropriateness, creative performance, creative products, or creative self-efficacy. Full-text, peer-reviewed reports published in English were considered, including records indexed from database inception through August 2026, with no publication-date restrictions.

Primary studies, narrative, scoping, or bibliometric reviews, protocols, editorials, theses, book chapters, and conference abstracts were excluded. Reviews were also excluded when they concerned adults or university students without separable evidence for participants younger than 18 years; examined ordinary or excessive screen use without an eligible creativity intervention; used technology only for assessment or data collection; reported problem solving, computational thinking, innovation, engagement, or collaboration without an explicit creativity outcome; or reviewed creativity interventions so broadly that the eligible digital component could not be separated at the review-synthesis level. These criteria were reapplied during final full-text checking (for 49 retrieved studies), and only the 15 reviews that directly matched the prespecified questions and provided sufficiently separable evidence were retained.

2.3. Search strategy

Scopus, ERIC, and the Web of Science Core Collection were searched from database inception through August 2026, with Google Scholar used as a supplementary source. The search strategies combined terms relating to children, adolescents, preschool, and K–12 populations; explicit creativity outcomes; digital technologies and technology-based educational interventions; and systematic reviews or meta-analyses. Search syntax and field specifications were adapted to each database's requirements, and the ERIC search was divided into seven complementary queries to cover the principal technology families. Two targeted searches were conducted in Google Scholar to identify potentially relevant reviews not retrieved from the bibliographic databases. No date, language, document-type, or other filters were applied during retrieval; eligibility restrictions were applied during screening. The complete database-specific search strings and query yields are provided in **Supplementary Table S1**.

2.4. Selection of reviews

Retrieved records were imported into Rayyan and duplicate records were removed before screening. One reviewer screened titles and abstracts and assessed full texts. To reduce avoidable exclusion error within a single-reviewer process, the prespecified criteria were applied through a conservative sequence: records were excluded at title and abstract only when ineligibility was clear; uncertain records were retained for full-text assessment; each full-text exclusion was assigned one standardized primary reason; and included and borderline records were rechecked against the same criteria before the final set was fixed. The database and supplementary-search pathways were documented separately in the PRISMA flow diagram **(Figure 1)**.

2.5. Data extraction

A standardized question-led form was used to record bibliographic and methodological information, in addition to intervention-related information. Information not stated in a review was recorded as “not reported” rather than inferred. See **Table 1** and **Table 2** for a detailed description. Effect estimates were retained in their originally reported metrics and synthesized narratively, with the included review as the unit of analysis. Reviews were grouped by their primary technology focus for descriptive presentation.

2.6. Methodological quality assessment

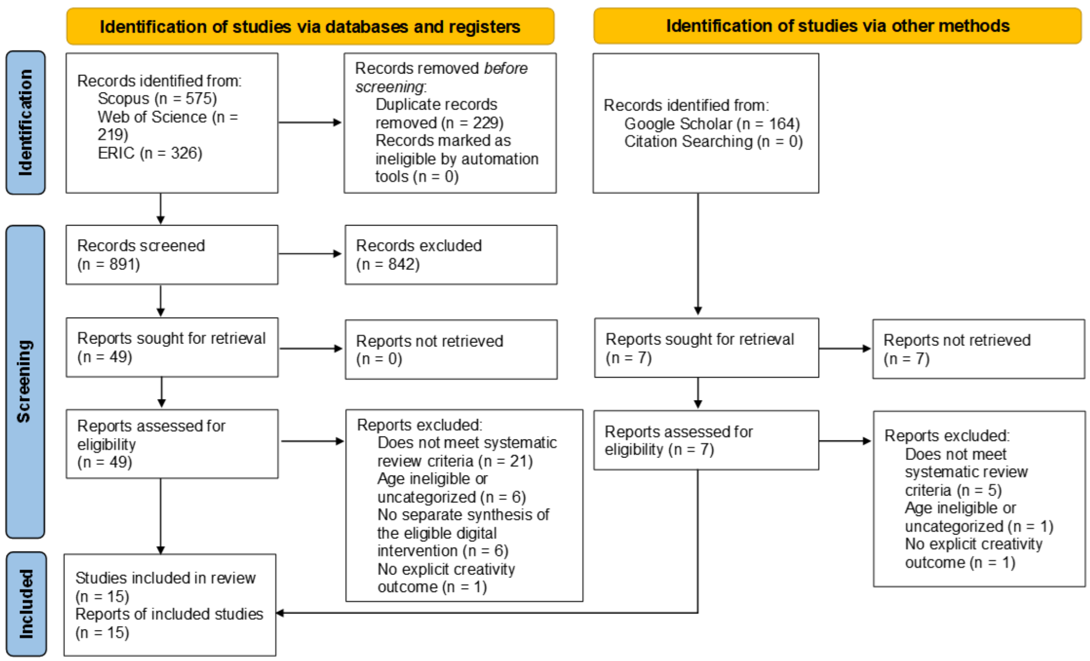
The methodological quality of each included review was assessed using the 11-item JBI Critical Appraisal Checklist for Systematic Reviews and Research Syntheses (Aromataris et al., 2024). The checklist assesses the review question, eligibility criteria, search methods, critical appraisal, data-extraction safeguards, synthesis methods, publication bias, and the adequacy of policy, practice, and research recommendations. Each item was rated as yes, no, unclear, or not applicable. Item-level judgments are presented in **Supplementary Table S2**.

3. Results

3.1. Study selection

The three database searches identified 1,120 records: 575 from Scopus, 219 from Web of Science, and 326 from ERIC. After 229 duplicates were removed, 891 records were screened, and 842 were excluded by title and abstract. Full texts were assessed for 49 database records; 34 were excluded because they did not meet the systematic-review criteria (n = 21), had ineligible or non-separable age groups (n = 6), did not separately synthesize an eligible digital intervention (n = 6), or lacked an explicit creativity outcome (n = 1). The supplementary Google Scholar searches identified 164 records. Seven were assessed in full and excluded because they were not systematic reviews (n = 5), had an ineligible or non-separable age group (n = 1), or lacked an explicit creativity outcome (n = 1). Therefore, 15 systematic reviews and meta-analyses were included in the final synthesis **(Figure 1)**.

Figure 1. *PRISMA 2020 flow diagram delineating the study selection process, which included searches of databases, registers, and other sources.*



3.2. Characteristics of included reviews

The 15 included reports comprised 10 meta-analyses and five systematic reviews published between 2019 and 2026. The characteristics of the included reviews were organized at two complementary levels. First, as shown in **Table 1**, bibliographic and methodological information was extracted, including publication details, search period, review design, number of included studies or effect sizes, aggregate sample size where reported, and the scope of child/adolescent or K–12 evidence.

Table 1. *Bibliographic, methodological and population characteristics.*

ID	Review	Search window	Design and size	Eligible child/adolescent population
1	Zhang & Zhu (2024; online 2022)	2011-2021	Meta-analysis; 20 studies; N = 3864	K-12 students
2	Peng et al. (2025)	NR	Meta-analysis; 56 studies; N = 9643	Preschool through university; K-12 subgroup estimates reported
3	Xiong et al. (2025)	2012-2023	Meta-analysis; 19 studies; N = 1595	Elementary through university; K-12 subgroups reported
4	Zaremohzzabieh et al. (2024)	2010-2023	Meta-analysis; 35 studies; N = 2776	School and college; school subgroup estimates reported
5	Sapounidis et al. (2025)	NR	Meta-analysis; 22 studies; N = 2192	Kindergarten only

ID	Review	Search window	Design and size	Eligible child/adolescent population
6	Yalcinalp & Avci (2019)	2013-2015	Systematic review; 37 studies; NR	12 K-12 articles; 18 university articles; other populations also included
7	Bal & Arseven (2026)	NR	Systematic review; 25 studies, NR	9 K-12 studies (1 elementary, 4 secondary, 4 high school); 16 university
8	Liu et al. (2022)	NR	Meta-analysis; 50 studies; N > 7000	Kindergarten through university; K-12 subgroups reported
9	Wang et al. (2024)	2014-2023	Meta-analysis; 62 studies; N = 7404	Preschool through university; K-12 subgroup estimates reported
10	Alshehri et al. (2026)	NR	Systematic review; 19 studies; N = 1695	9 K-12 studies (3 elementary, 6 secondary); 10 higher education
11	Chai et al. (2026)	NR	Meta-analysis; 32 studies; N = 4099	Middle school and university; 6 middle-school effect sizes
12	Lin et al. (2024)	2002-2022	Meta-analysis; 29 studies; N = 4159	25 K-12 studies (4 kindergarten, 15 elementary, 6 high school); 3 higher education; 1 other
13	Li et al. (2022)	2010-2020	Systematic review; 32 studies; N = 2418	13 K-12 studies (1 Pre-K, 5 elementary, 3 middle, 4 high school); 19 higher education
14	Fielding & Murcia (2022)	2010-2020	Systematic review; 19 studies; NR	Young children aged 3-8; intended focus: 4-8
15	Chen et al. (2026)	NR	Meta-analysis; 29 studies; NR	40 K-12 effect sizes (4 preschool, 31 elementary, 5 secondary); 5 higher education; 4 mixed

Note. ID = unique identifier assigned to each review; NR = not reported; K–12 = schooling from kindergarten through Grade 12. When a review included university students, only explicitly reported K–12 subgroup evidence was used for developmental interpretation.

Second, intervention-related information was extracted, including the digital technology, its active and pedagogical role, implementation setting or environment, creativity outcomes and measurement approaches, relevant to children and adolescents **(Table 2)**.

Table 2. *Technology, implementation setting, and creativity measurement.*

ID	Digital intervention	implementation features	Implementation setting	Creativity outcomes and measurement
1	Educational robotics	Active construction/programming with educational robots; creativity-specific effect separated from problem solving, but age/duration	K–12 school interventions; physical setting was not compared quantitatively.	Creativity and problem solving; creativity reported separately. Measures varied

ID	Digital intervention	implementation features	Implementation setting	Creativity outcomes and measurement
		moderators combined both outcomes.		across primary studies.
2	AI-supported instruction, including pre-generative and generative AI	AI as teacher assistant, learner assistant, or intelligent virtual experience within instruction; active pedagogical support rather than measurement-only use.	Preschool to university instructional settings; K–12 subgroups reported. Physical location was not meta-analyzed.	Creative thinking; divergent and convergent outcomes.
3	VR and AR	Immersive VR/AR used for active learning, simulation, and creation; project-based learning and teacher instruction were prominent design categories.	Elementary through university, mainly formal instruction; physical location was not pooled.	Overall creativity; instruments included TTCT, Wallach–Kogan, TCT-DP, interviews, and self-report questionnaires.
4	Interactive learning environments, digital instruction/platforms, games/robotics	Broad educational-technology interventions, including interactive environments, digital instruction/platforms, games and robotics.	School and college contexts; school subgroup extractable. Physical setting not directly compared.	TTCT total and subscales: fluency, flexibility, originality and elaboration.
5	Real educational robots	Hands-on educational robotics activities in kindergarten; creativity was one of the 4C outcomes.	Kindergarten/early-childhood educational contexts; physical setting not compared.	Creativity reported separately; primary-study measures were heterogeneous.
6	Robotics, social/collaborative tools, learning technologies, visualization, internet, games, mobile apps	Robotics, collaborative/web tools, visualization, games, mobile apps and other emerging digital technologies used in learning activities.	Mixed formal education contexts; 12 K–12 studies and 18 university studies. Setting evidence was descriptive.	Questionnaires/scales, observations, video/log data and rubrics; broad creativity/performance outcomes.
7	AI-assisted writing, ChatGPT, multimodal/generative platforms, Poetry Machine	AI-assisted writing and multimodal generation (e.g., ChatGPT/LLMs, DALL-E, Poetry Machine) used for ideation, drafting and production.	Writing instruction from elementary school to university; nine K–12 studies.	Writing creativity, originality, flexibility, elaboration/detail, imagination, idea

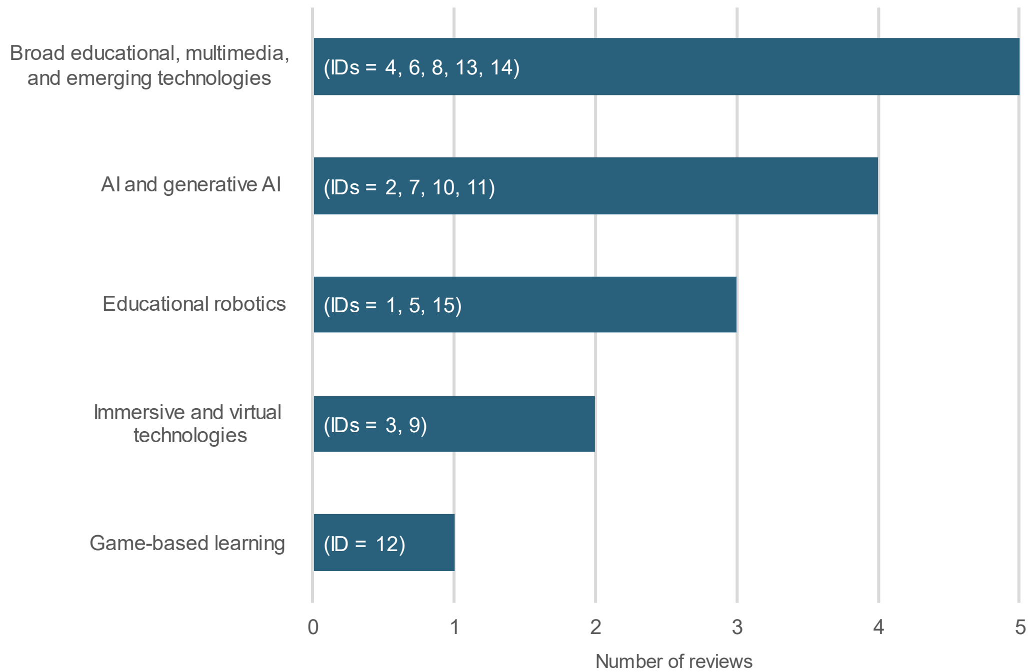
ID	Digital intervention	implementation features	Implementation setting	Creativity outcomes and measurement
			Physical setting not quantified.	generation and creative production.
8	Multimedia technology, including CAI, programming, VR and other tools	Multimedia technology spanning CAI, programming, VR, games and creative-support systems; active interaction contrasted with passive watching.	Kindergarten through university educational contexts; physical setting not analyzed.	Divergent and convergent thinking, creative problem solving, fluency, flexibility, originality, elaboration and usefulness.
9	Desktop, immersive, distributed VR; AR; MR	Desktop/immersive/distributed VR, AR and MR; operational, observational and social learning; inquiry/task/mentor methods and feedback designs.	Preschool through university formal education; physical location not directly compared.	Innovative thinking, practical ability and personality-related qualities.
10	LLMs, visual generative AI, and specialized AI platforms	LLMs, visual generative AI and specialized AI platforms embedded in creative pedagogy/digital-humanities activities.	Formal education; three elementary and six secondary studies plus higher education. Setting not quantitatively compared.	Fluency, flexibility, originality, elaboration, problem sensitivity and domain-specific creativity.
11	GenAI-assisted learning	GenAI used either as a direct tool or embedded in a learning application; collaborative and independent arrangements compared.	Middle school and university; six middle-school effects. Physical setting not analyzed.	Innovative thinking, practical ability and personality traits, objective, subjective and mixed assessment.
12	Game learning, including Game-based learning, digital game-based learning and gamification; some non-digital games	Game-based learning, digital game-based learning and gamification; digital content and PBL/PjBL-plus-collaboration examined as moderators.	Mostly K–12 formal education; physical classroom/laboratory location not compared.	Overall creativity; common tools included TTCT, but cognitive and affective dimensions were not separated.
13	Web 2.0, wearable VR, games/simulations, production software, multimedia, web	Web 2.0, wearable VR, games/simulations, production software, multimedia, web instruction, and visual-thinking tools	Pre-K–16 educational settings; 13 K–12 studies. Physical location not	Originality, fluency, flexibility, elaboration, general/content-specific creativity.

ID	Digital intervention	implementation features	Implementation setting	Creativity outcomes and measurement
	instruction, visual-thinking tools	integrated at varying TIM levels.	quantitatively compared.	
14	Tangible robotics/coding, virtual coding, smart toys, tablets, computers, games, interactive whiteboards, 3D printing	Tangible/virtual coding, robotics, smart toys, tablets, computers, games, interactive whiteboards and 3D printing; adult/peer scaffolding supported child agency.	Kindergarten, early-learning center, primary school, and library contexts could overlap.	Process-oriented A–E framework: Agency, being curious, Connecting, Daring and Experimenting; limited person/product/place evidence.
15	Educational robots	Educational robots used as active tools within programming/robotics and guided, problem-based or mixed strategies; robot role and modeled skills examined.	Direct comparison: classroom, laboratory, and other contexts.	Creativity outcomes; cognition-only versus mixed cognitive + creativity measurement categories.

Note. ID = unique identifier assigned to each review; K–12 = schooling from kindergarten through Grade 12; AI = artificial intelligence; VR = virtual reality; AR = augmented reality; CAI = computer-assisted instruction; GenAI = generative artificial intelligence; MR = mixed reality; TTCT = Torrance Tests of Creative Thinking; LLM = large language model; TIM = Technology Integration Matrix.

The 15 included reviews were distributed across five primary technology families **(Figure 2)**: broad educational, multimedia, and emerging technologies (n = 5), AI and generative AI (n = 4), educational robotics (n = 3), immersive and virtual technologies (n = 2), and game-based learning (n = 1). Review IDs within each family are shown in the figure.

Figure 2. *Distribution of included reviews by primary technology family.*



Note. IDs correspond to Tables 1 and 2. Families reflect each review's primary scope. Broad reviews may include more than one technology type.

3.3. Methodological quality of included reviews

Methodological quality varied across the included reviews **(Supplementary Table S2)**. All 15 reviews had a clear question and appropriate inclusion criteria, while 14 used an appropriate search strategy and adequate information sources. The main weaknesses in critical appraisal are that only five reviews used appropriate appraisal criteria, and five clearly reported independent appraisal by at least two reviewers. Data extraction safeguards were reported in 11 reviews, were unclear in one, and were not adequately reported in three. Twelve reviews used appropriate synthesis methods, and 12 assessed or otherwise addressed publication bias. Practice recommendations were supported by the reported findings, and directions for future research were appropriate across all reviews.

3.4. Findings by research questions

Findings of this research are presented below according to the *four* research questions:

RQ1: Direction, magnitude, and consistency across technology families

Across the reviews, positive average effects of digital interventions on creativity were generally reported. All 10 meta-analyses reported standardized mean differences (SMDs) for the principal creativity outcomes. Eight explicitly reported Hedges' g (Chai et al., 2026; Lin et al., 2024; Liu et al., 2022; Sapounidis et al., 2025; Wang et al., 2024; Xiong et al., 2025; Zaremohzzabieh et al., 2025; Zhang & Zhu, 2024), whereas two reported the metric as SMD (Chen et al., 2026; Peng et al., 2025). The five systematic reviews used narrative or thematic synthesis without a common pooled estimate (Alshehri et al., 2026; Fielding & Murcia, 2022; Li et al., 2022; Bal & Arseven, 2026; Yalcinalp & Avci, 2019). None of the included reviews reported an odds ratio for the principal creativity outcomes.

Most overall estimates were moderate, although some were larger. Positive findings were reported for educational robotics, AI-supported instruction, immersive and virtual technologies, multimedia, broader educational technology, and game learning (Chai et al., 2026; Chen et al., 2026; Lin et al., 2024; Liu et al., 2022; Peng et al., 2025; Sapounidis et al., 2025; Wang et al., 2024; Xiong et al., 2025; Zaremohzzabieh et al., 2025; Zhang & Zhu, 2024).

Additionally, the systematic reviews broadly supported this positive direction but also showed that benefits depended on how the technology was used and embedded in instruction (Alshehri et al., 2026; Fielding & Murcia, 2022; Li et al., 2022; Bal & Arseven, 2026; Yalcinalp & Avci, 2019). Heterogeneity was substantial in several meta-analyses, and the reviews differed in age coverage, interventions, outcomes, and analytical models. The evidence therefore supports a generally beneficial role for digital technologies, but not a reliable ranking of technology families.

RQ2: Developmental patterns

Age-related patterns were inconsistent across technology families. Some reviews reported larger estimates in preschool or kindergarten samples, whereas others found little difference between educational levels, larger estimates in older groups, or no statistically clear differences between levels (Chen et al., 2026; Lin et al., 2024; Liu et al., 2022; Peng et al., 2025; Wang et al., 2024; Xiong et al., 2025; Zhang & Zhu, 2024). Some age-group findings were based on too few studies to support firm conclusions, and some reviews included university samples. The available evidence, therefore, indicates developmental sensitivity but does not establish a consistent age gradient or identify one age group as the most responsive.

RQ3: Outcome specificity and measurement

The evidence was mostly concentrated on divergent thinking and its common components, particularly originality, fluency, flexibility, and elaboration. Convergent thinking and broader outcomes related to creative products, performance, or personal characteristics received less attention (Li et al., 2022; Liu et al., 2022; Peng et al., 2025). Measures also varied across tests, ratings, task products, and broad innovation categories, limiting direct comparison between reviews.

The quality and consistency of creativity measurement varied considerably across studies. Li et al. (2022) noted incomplete reporting of reliability and effect sizes in primary studies, whereas Fielding and Murcia (2022) showed that young children’s creativity was often represented through observable creative processes rather than psychometric scores alone. These differences support outcome-specific interpretation and caution against treating all creativity measures as interchangeable.

RQ4: Design, implementation, duration, and setting

Across reviews, findings were more favorable when learners actively created, manipulated, or solved problems with technology rather than mainly observing digital content. The reviews also reported more favorable results when digital activities involved projects, inquiry, or clearly defined tasks and were supported by feedback, scaffolding, collaboration, or teacher guidance (Chai et al., 2026; Lin et al., 2024; Liu et al., 2022; Wang et al., 2024; Xiong et al., 2025). However, these elements were examined in only some reviews and were not assessed consistently.

Intervention duration did not show a consistent pattern, and no optimal exposure period could be identified. In addition, implementation setting was rarely examined directly. Chen et al**.** (2026) reported stronger effects for classroom-based robotics than for laboratory and other settings, but no comparable setting contrast was available for the other technology families. Classroom integration may therefore be advantageous, possibly through closer curricular alignment and teacher support, but this mechanism was not directly tested, and a general setting effect cannot yet be established.

4. Discussion

This umbrella review was conducted to provide an integrated account of how digital technology interventions may support creativity in children and adolescents. Findings from 15 systematic reviews and meta-analyses were synthesized to examine effects across technology families, developmental patterns, creativity outcomes and measures, and the role of intervention design and setting.

Findings showed that digital technology interventions were generally associated with improvements in creativity, but no technology family could be identified as the most effective. For example, Peng et al., 2025, reported a positive moderate effect for AI-supported instruction, whereas Xiong et al., 2025, reported a larger effect for immersive technologies. However, this difference should not be interpreted as a direct advantage of immersive technology because the two reviews differed in their age ranges, interventions, and creativity outcomes. Put differently, several technology families can support creativity, although the magnitude and consistency of their effects vary.

Additionally, the way technology was used appeared to be as important as the type of technology itself. Liu et al. (2022) found more favorable effects for active multimedia use than for passive viewing, while Chai et al. (2026) reported stronger effects when generative AI was embedded within a learning application rather than used directly. These similar findings suggest that technology may be more beneficial when learners actively create, solve problems, receive support, and remain involved in evaluating and revising their ideas. Nevertheless, because these features were not examined consistently across the included reviews, they should be considered recurring patterns rather than confirmed explanations.

The findings did not support a consistent relationship between age and the effectiveness of digital interventions. Wang et al. (2024) reported the largest estimate among preschool children, whereas Lin et al. (2024) reported the largest game-based learning estimate among high-school students. This difference may reflect variations in the technologies, learning activities, creativity measures, and number of studies included in each subgroup. Therefore, the findings suggest that developmental appropriateness may be more important than age alone. A technology may be effective when its tasks, level of complexity, and available support are suited to the developmental abilities of the learners.

The effectiveness of digital interventions also depended on how creativity was defined and measured. Li et al. (2022) showed that the evidence was mainly concentrated on originality, fluency, flexibility, and elaboration, while also identifying incomplete reporting of measurement reliability in several studies. Similarly, Peng et al. (2025) included substantially more studies of divergent than convergent thinking. Moreover, Liu et al. (2022) reported positive effects for originality and creative products but less certain findings for flexibility and usefulness. By comparison, Fielding and Murcia (2022) described creativity in young children through observable processes such as agency, curiosity, connection-making, and experimentation. These differences reflect the multidimensional nature of creativity and the need for developmentally appropriate assessment. An improvement in one component should therefore not be interpreted as an improvement in creativity as a whole.

The evidence concerning intervention duration and setting was limited and did not support a general rule. Xiong et al. (2025) found that effects varied across duration categories, although several categories were based on only one or two studies. Chen et al. (2026) reported the largest robotics estimate for interventions lasting 8–16 weeks, suggesting that duration may matter, but this pattern was not established across other technology families. Attention to setting was even more limited. Although several reviews reported whether interventions were conducted in classrooms, laboratories, homes, or other contexts, settings were generally described rather than directly compared. Among the 15 included reviews, only Chen et al. (2026) examined setting as a moderator and reported a larger estimate for classroom-based interventions than for laboratory and other settings. Fielding and Murcia (2022), for example, discussed early-learning settings and the support surrounding children's technology use but did not compare the effectiveness of different settings. This limited attention may reflect inconsistent reporting of setting in primary studies and the difficulty of separating the effect of location from instructional design and intervention duration. Examining setting more directly would be useful because these conditions may influence learners' engagement with technology and the extent to which its use is connected to meaningful educational activities. It could also help determine whether stronger outcomes result from the technology itself or from the support and learning conditions available in the surrounding environment.

Overall, developmental fit appeared more important than any single age group, evidence was clearest for divergent thinking outcomes. Additionally, active, structured, and supported technology use emerged as the most consistent favorable condition. Duration appeared technology- and outcome-specific, while the classroom advantage observed for educational robotics could not yet be generalized across technology families.

4.1. Strengths and limitations

This umbrella review has several strengths and limitations that should be considered. It used a research-question-led, outcome-specific approach to extract evidence from 15 directly eligible reviews. No additional eligible reviews were identified through supplementary searches beyond the selected databases, supporting the comprehensiveness of the search strategy. In addition, the conservative review process, including the rechecking of borderline records and the use of standardized exclusion and extraction rules, strengthened consistency across decisions.

Regarding the limitations, study selection, data extraction, and methodological appraisal were conducted by one reviewer, which may have increased the possibility of error or subjective judgment. The restriction to English-language publications may also have reduced the generalizability of the findings. Moreover, several reviews combined K–12 and university populations, which limited the interpretation of findings specifically related to children and adolescents. Some subgroup sample sizes also referred to numbers of effects rather than independent studies, potentially giving an inflated impression of the amount of available evidence.

4.2. Future research

Future research should directly test the recurring patterns identified in this review, particularly the apparent benefits of active, structured, and supported technology use. Studies should use clearly defined and developmentally appropriate measures and report intervention duration, setting, learner interaction, teacher support, and collaboration more consistently. Direct comparisons across age groups and educational settings, together with longer-term follow-up, would make the evidence more useful for both educational practice and designing more effective interventions to enhance creativity.

5. Conclusion

This umbrella review synthesized evidence from 15 systematic reviews and meta-analyses identified through systematic searches of Scopus, ERIC, and Web of Science. The findings indicate that digital interventions generally supported creativity in children and adolescents, although no technology family was consistently superior. Findings varied across developmental groups and outcomes, but were generally more favorable when technology was used actively within structured and supported learning activities; the evidence base was clearest for divergent-thinking outcomes. Duration appeared technology- and outcome-specific, while the classroom advantage observed for educational robotics could not yet be generalized across technology families.

This may help both educators and researchers to select digital interventions based not only on the technology itself, but also on the creativity outcome, developmental group, and conditions under which the intervention is implemented.

Data Availability and Supplementary Data

The datasets of this study are available from the author upon reasonable request. **Supplementary Table S1** contains the complete search strategies, and **Supplementary Table S2** presents the item-level JBI methodological appraisal of the included reviews.

References

**References marked with an asterisk were included in this umbrella review.*

Aguilar, D., & Pifarre Turmo, M. (2019). Promoting social creativity in science education with digital technology to overcome inequalities: A scoping review. *Frontiers in Psychology*, *10*, 1474. https://doi.org/10.3389/fpsyg.2019.01474

*Alshehri, H. A., Alsubaie, F. B. S. M., Abdellatif, M. S., & Nemt-allah, M. A. (2026). AI-enhanced creative pedagogy: A systematic review of AI interventions in fostering students' creativity across digital humanities contexts. *Research Journal in Advanced Humanities*, *7*(1). https://doi.org/10.58256/738q2y02

Alves-Oliveira, P., Arriaga, P., Xavier, C., Hoffman, G., & Paiva, A. (2022). Creativity landscapes: Systematic review spanning 70 years of creativity interventions for children. *The Journal of Creative Behavior*, *56*(1), 16-40. https://doi.org/10.1002/jocb.514

Aromataris E, Lockwood C, Porritt K, Pilla B, Jordan Z, editors. (2024). JBI Manual for Evidence Synthesis. JBI. https://synthesismanual.jbi.global.

*Bal, M., & Arseven, T. (2026). Students' writing skills and creativity in the age of artificial intelligence: A systematic review of creativity across diverse AI-supported writing contexts. *Thinking Skills and Creativity*, 102118. https://doi.org/10.1016/j.tsc.2025.102118

Benedek, M., Karstendiek, M., Ceh, S. M., Grabner, R. H., Krammer, G., Lebuda, I., Silvia, P. J., Cotter, K. N., Li, Y., Hu, W., Martskvishvili, K., & Kaufman, J. C. (2021). Creativity myths: Prevalence and correlates of misconceptions on creativity. *Personality and Individual Differences*, *182*, 111068. https://doi.org/https://doi.org/10.1016/j.paid.2021.111068

*Chai, H., Guo, F., Wang, J., Song, X., & Hu, T. (2026). Uncovering the effect of Gen AI-assisted learning on students' creativity: A meta-analysis from quasi-experimental evidence. *Thinking Skills and Creativity*, 102227. https://doi.org/10.1016/j.tsc.2026.102227

*Chen, X., Xie, H., Tao, X., Li, L., Peng, X., & Wang, F. L. (2026). Educational robots for student creativity development. *Educational Technology & Society*, *29*(3), 361-382. http://doi.10.30191/ETS.202607_29(3).SP11

Cramman, H., Menzies, V., Gray, H., Mee, D., & Eerola, P. (2020). Baseline Evaluation of the Durham Commission on Creativity and Education Report. http://doi:10.15128/r2gm80hv372

Eyre, H., Faulkenberg, M., Das, S., Hackett, J., Chen, S., Véron, F., Swieboda, P., Ling, G., Bennett, E., Saxena, S., Carnevale, S., Powell, E., Smith, E., Ibanez, A., Wong, S., Storch, E., Chan, E., Heinemeyer, M., Robertson, I., & Berk, M. (2022). Brain Capital: An Emerging Investment Opportunity. *Psychiatric Times*, *Online First*.

Eyre, H. A., Ayadi, R., Ellsworth, W., Aragam, G., Smith, E., Dawson, W. D., Ibanez, A., Altimus, C., Berk, M., Manji, H. K., Storch, E. A., Leboyer, M., Kawaguchi, N., Freeman, M., Brannelly, P., Manes, F., Chapman, S. B., Cummings, J., Graham, C., . . . Hynes, W. (2021). Building brain capital. https://dro.deakin.edu.au/articles/journal_contribution/Building_brain_capital/20666370

*Fielding, K., & Murcia, K. (2022). Research linking digital technologies to young children's creativity: An interpretive framework and systematic review. *Issues in Educational Research*, *32*(1), 105-125. https://search.informit.org/doi/10.3316/informit.475656822715647

Green, A. E., Beaty, R. E., Kenett, Y. N., & Kaufman, J. C. (2024). The process definition of creativity. *Creativity Research Journal*, *36*(3), 544-572. https://doi.org/10.1080/10400419.2023.2254573

Gu, X., Ritter, S. M., & Dijksterhuis, A. (2024). Online creativity training: Examining the effectiveness of a comprehensive training approach. *International Journal of Technology and Design Education*, *34*(1), 403-426. https://doi.org/10.1007/s10798-023-09820-2

Harvey, S., & Berry, J. W. (2023). Toward a meta-theory of creativity forms: How novelty and usefulness shape creativity. *Academy of Management Review*, *48*(3), 504-529. https://doi.org/10.5465/amr.2020.0110

Hendriyani, M. E., Rifqiawati, I., & Lestari, D. (2022). Online learning videos to develop creative thinking skills of students. *Research and Development in Education (RaDEn)*, *2*(2), 67-75. https://doi.org/10.22219/raden.v2i2.20035 https://doi.org/10.22219/raden.v2i2.20035

Henriksen, D., Creely, E., Henderson, M., & Mishra, P. (2021). Creativity and technology in teaching and learning: a literature review of the uneasy space of implementation. *Educational Technology Research and Development*, 1-18. https://doi.org/10.1007/s11423-020-09912-z

Karunarathne, W., & Calma, A. (2024). Assessing creative thinking skills in higher education: deficits and improvements. *Studies in Higher Education*, *49*(1), 157-177. https://doi.org/10.1080/03075079.2023.2225532

Larraz, N. (2021). Development of Creative Thinking Skills in the Teaching-Learning Process. In. https://doi.org/10.5772/intechopen.97780

Larsen, B., & Luna, B. (2018). Adolescence as a neurobiological critical period for the development of higher-order cognition. *Neurosci Biobehav Rev*, *94*, 179-195. https://doi.org/10.1016/j.neubiorev.2018.09.005

Li, P., He, G., Sun, Y., & Ziegler, A. (2025). Both science and art elicit emotional well-being: An examination of creativity and mood. *Psychology of aesthetics, creativity, and the arts*. https://doi.org/10.1037/aca0000820

*Li, Y., Kim, M., & Palkar, J. (2022). Using emerging technologies to promote creativity in education: A systematic review. *International Journal of Educational Research Open*, *3*, 100177. http://doi.10.1016/j.ijedro.2022.100177

Lilly, F. R. (2019). Creativity and cognitive development in adolescence. *The Encyclopedia of Child and Adolescent Development*, 1-10. https://doi.org/10.1002/9781119171492.wecad371

*Lin, I.-C., Chang, S.-H., Liu, P.-C., Kuo, P.-J., & Chung, K. C. (2024). Exploring the effectiveness and moderators of game learning on creativity enhancement. *Educational Technology & Society*, *27*(3), 83-101. https://www.jstor.org/stable/48787018

*Liu, M., Pang, W., Guo, J., & Zhang, Y. (2022). A meta-analysis of the effect of multimedia technology on creative performance. *Education and Information Technologies*, *27*(6), 8603-8630. https://doi.org/10.1007/s10639-022-10981-1

Mejia, C., D'Ippolito, B., & Kajikawa, Y. (2021). Major and recent trends in creativity research: An overview of the field with the aid of computational methods. *Creativity and Innovation*

Management, *30*(3), 475-497. https://doi.org/10.1111/caim.12453

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., & Brennan, S. E. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *bmj*, *372*. https://doi.org/10.1136/bmj.n71

Paz-Baruch, N., & Maor, R. (2023). Cognitive abilities and creativity: The role of working memory and visual processing. *Thinking Skills and Creativity*, *48*, 101294. https://doi.org/10.1016/j.tsc.2023.101294

*Peng, Y., Wang, X., Chen, J., Wang, Y., Dong, Z., Wang, Y., Lyu, S., & Wang, W. (2025). The impact of AI-supported instructional interventions on students' creative thinking: A meta-analysis of 56 experimental studies. *Journal of Research on Technology in Education*, 1-25. https://doi.org/10.1080/15391523.2025.2557392

Rawlings, B., S., Chetwynd-Talbot, D., Husband, E., Nuttall, A., Quinn, E., Taggart, R., & Roome, H. E. (2025). Divergent thinking is linked with convergent thinking; implications for models of creativity. *Thinking & Reasoning*, 1-23. https://doi.org/10.1080/13546783.2025.2485059

Rethlefsen, M. L., Kirtley, S., Waffenschmidt, S., Ayala, A. P., Moher, D., Page, M. J., & Koffel, J. B. (2021). PRISMA-S: an extension to the PRISMA statement for reporting literature searches in systematic reviews. *Systematic reviews*, *10*(1), 39. https://doi.org/10.1186/s13643-020-01542-z

*Sapounidis, T., Rapti, S., & Vaiopoulou, J. (2025). Effects of educational robotics on kindergarteners' collaboration, communication, critical thinking, and creativity: A meta-analysis. *Journal of Science Education and Technology*, *34*(1), 73-87. https://doi.org/10.1007/s10956-024-10149-1

Sio, U. N., & Lortie-Forgues, H. (2024). The impact of creativity training on creative performance: A meta-analytic review and critical evaluation of 5 decades of creativity training studies. *Psychological Bulletin*. https://doi.org/10.1037/bul0000432

Sitorus, L. S., Sipahutar, M. I., Nasution, S. N., Purnama, L., & Iskandar, T. (2025). Literature review on the use of technology-based learning media in the context of distance learning. *Jurnal Medika: Medika*, *4*(3), 283-289. https://doi.org/10.31004/bkxg7355

Smith, E., Ali, D., Wilkerson, B., Dawson, W. D., Sobowale, K., Reynolds, C., Berk, M., Lavretsky, H., Jeste, D., Ng, C. H., Soares, J. C., Aragam, G., Wainer, Z., Manji, H. K., Licinio, J., Lo, A. W., Storch, E., Fu, E., Leboyer, M., . . . Eyre, H. A. (2021). A Brain Capital Grand Strategy: toward economic reimagination. *Molecular Psychiatry*, *26*(1), 3-22. https://doi.org/10.1038/s41380-020-00918-w

Tang, C., Mao, S., Xing, Z., & Naumann, S. (2022). Improving student creativity through digital technology products: A literature review. *Thinking Skills and Creativity*, 101032. https://doi.org/10.1016/j.tsc.2022.101032

Thornhill-Miller, B., Camarda, A., Mercier, M., Burkhardt, J.-M., Morisseau, T., Bourgeois-Bougrine, S., Vinchon, F., El Hayek, S., Augereau-Landais, M., Mourey, F., Feybesse, C., Sundquist, D., & Lubart, T. (2023). Creativity, Critical Thinking, Communication, and Collaboration: Assessment, Certification, and Promotion of 21st Century Skills for the Future of Work and Education. *Journal of Intelligence*, *11*(3), 54.

https://www.mdpi.com/2079-3200/11/3/54

Timotheou, S., Miliou, O., Dimitriadis, Y., Sobrino, S. V., Giannoutsou, N., Cachia, R., Monés, A. M., & Ioannou, A. (2023). Impacts of digital technologies on education and factors influencing schools' digital capacity and transformation: A literature review. *Educ Inf Technol (Dordr)*, *28*(6), 6695-6726. https://doi.org/10.1007/s10639-022-11431-8

*Wang, Y., Liu, W., Yu, X., Li, B., & Wang, Q. (2024). The impact of virtual technology on students' creativity: A meta-analysis. *Computers & Education*, *215*, 105044. https://doi.org/10.1016/j.compedu.2024.105044

*Xiong, J., Wen, J., Han, X., Cui, W., Pei, G., & Tao, Z. (2025). Effect of immersive technology on students' creativity: A meta-analysis. *SAGE Open*, *15*(3), 21582440251361624. https://doi.org/10.1177/215824402513616

*Yalcinalp, S., & Avci, Ü. (2019). Creativity and emerging digital educational technologies: A systematic review. *Turkish Online Journal of Educational Technology-TOJET*, *18*(3), 25-45.

Yeo, G. B., Celestine, N. A., Parker, S. K., To, M. L., & Hirst, G. (2024). A neurocognitive framework of attention and creativity: Maximizing usefulness and novelty via directed and undirected pathways. *Journal of Organizational Behavior*, *45*(6), 912-934. https://doi.org/10.1002/job.2787

*Zaremohzzabieh, Z., Ahrari, S., Abdullah, H., Abdullah, R., & Moosivand, M. (2025). Effects of educational technology intervention on creative thinking in educational settings: a meta-analysis. *Interactive Technology and Smart Education*, *22*(2), 235-265. https://doi.org/10.1108/ITSE-11-2023-0224

*Zhang, Y., & Zhu, Y. (2024). Effects of educational robotics on the creativity and problem-solving skills of K-12 students: A meta-analysis. *Educational Studies*, *50*(6), 1539-1557. https://doi.org/10.1080/03055698.2022.2107873