GAWI
Journal of Action Research
Vol. 6 No. 1 2026

Sustainability Consciousness and Creativity in Education: Evidence, Gaps, and a Research Agenda, with Implications for Science Education

Muhammad Fuad Sya'ban[1,2], Adi Rahmat[1*], Siti Sriyati[1], and Omay Sumarna[1]

[1] Doctoral Program of Science Education, Faculty of Mathematics and Science Education, Universitas Pendidikan Indonesia, Bandung, Indonesia
[2] Department of Science Education, Faculty Teacher Training and Education, Universitas Lambung Mangkurat, Banjarmasin, Indonesia

*adirahmat@upi.edu

Received	Accepted	Published
03/06/2026	17/06/2026	31/07/2026

DOI
10.59329/gawi.v6i1/333

ABSTRACT

Education for sustainability requires learners who are both conscious of sustainability and able to generate creative responses to complex socio-ecological problems, yet how these two capacities relate remain unclear and scattered across disconnected studies. This systematic review synthesized empirical research on the relationship between sustainability consciousness and student creativity in formal secondary-to-tertiary education. Following PRISMA 2020, Scopus and Web of Science were searched (2015–2026); records were screened in two stages, appraised with the Mixed Methods Appraisal Tool, and combined through thematic synthesis. Eleven studies met the criteria. Across diverse subjects and countries, the two constructs were consistently and positively associated, although the reported direction varied sustainability consciousness predicting creativity, creativity predicting sustainability consciousness, and the two co-developing under shared interventions. However, sustainability was operationalized inconsistently, no study employed the full tripartite sustainability-consciousness construct, and cross-sectional designs precluded causal inference. The review exposes a fragmented evidence base and the absence of an integrative framework. It calls for mechanism-based, longitudinal designs that align comprehensive sustainability-consciousness and creativity measures, and recommends active, integrative pedagogies for cultivating both capacities across diverse subjects, with particular relevance for science education.

Keywords: creativity; environmental literacy; science education; sustainability consciousness; systematic review

How to cite:
Sya'ban, M. F., Rahmat, A., Sriyati, S., & Sumarna, O. (2026). Sustainability Consciousness and Creativity in Education: Evidence, Gaps, and a Research Agenda, with Implications for Science Education. *Gawi: Journal of Action Research*, *6*(1), 80-102

INTRODUCTION

Humanity faces interlocking environmental, social, and economic crises whose resolution depends on how the next generation learns to think and act. Education is widely positioned as a central lever for this transition, and education for sustainable development (ESD) has accordingly moved from the margins to the core of curricular and policy agendas worldwide (Ameer & Ghannam, 2025; Hu & Mou, 2025; Nepraš et al., 2022). A consistent theme in this literature is that sustainability transformation is driven not only by knowledge but by the values, dispositions, and competencies that schooling cultivates (Horcea-Milcu, 2022). ESD scholarship has therefore converged on a set of "key competencies in sustainability" that learners must develop to act responsibly in complex systems (Birdman et al., 2022; Pacis & VanWynsberghe, 2020), competencies now formalized in frameworks such as the European GreenComp and operationalized in school-level instruments (Martín-Ramos et al., 2025; Sass et al., 2021; Toma et al., 2024).

Within this agenda, *sustainability consciousness* (SC) has emerged as an integrative construct that captures an individual's knowingness, attitudes, and behavior across the environmental, social, and economic dimensions of sustainability (Gericke et al., 2019). Because it unifies cognitive, affective, and behavioral facets in a single, validated framework, SC has become an increasingly common lens for assessing how students relate to sustainability (Arantes & Sousa, 2025; Eraslan et al., 2024; Ovais, 2023). Cultivating SC, however, is only half of what education for sustainability requires: learners must also be able to *generate* and enact novel responses to problems that are open-ended, contested, and unprecedented.

This is where creativity becomes pivotal. Creativity, the capacity to produce work that is both novel and effective (Runco, 2025) is consistently identified among the core competencies for twenty-first-century learning and work (Piirto, 2021; Tight, 2021). Beyond its economic framing, creativity is increasingly theorized as a competence *for* sustainability: addressing "wicked" socio-ecological problems demands divergent thinking, imagination, and the ability to envision alternative futures (Mróz & Ocetkiewicz, 2021, 2024). Schools and universities have responded by embedding creativity in STEAM, science, and project-based designs and by refining how it is taught and assessed (Niu & Cheng, 2022; Saeed & Ramdane, 2022; Sipahi & Bahar, 2025; Wu et al., 2025).

There are strong conceptual reasons to expect SC and creativity to be linked. Sustainability problems are ill-structured and value-laden, so translating awareness into action plausibly requires creative problem-solving rather than the application of routine solutions. Conversely, affective engagement with environmental issues, including emotions such as eco-anxiety and eco-anger can mobilize the motivation that underpins creative effort and pro-environmental behavior (Contreras et al., 2024; Stanley et al., 2021). A growing number of classroom studies have begun, often independently, to measure both constructs and to probe their association across diverse subjects and educational levels.

Yet this emerging evidence base is fragmented in ways that impede cumulative progress. First, the sustainability construct is operationalized inconsistently as environmental literacy, ecological literacy, sustainability awareness, or sustainability attitudes so that ostensibly comparable studies in fact measure different things, and the comprehensive, validated SC construct is rarely used in studies that also examine creativity. Second, the studies are scattered across disciplines and methods, with no shared model specifying *how* SC and creativity relate, in which direction, or through what mechanisms. Third, the two relevant review literatures have advanced in isolation. On the sustainability side, recent systematic reviews have mapped ESD and sustainability competencies and the design of transformative learning in higher education (Bernert et al., 2022), climate-change education (Ameer & Ghannam, 2025; Nepraš et al., 2022), outdoor education for sustainable development (Hu & Mou, 2025), and sustainable inclusive education (Işıkgöz & Öztunç, 2026); yet none treats creativity as a paired, measured outcome. On the creativity side, reviews have synthesized the effects of creative-thinking instructional models (Saeed & Ramdane, 2022) and the definitions, frameworks, and assessment of (mathematical) creativity (Sipahi & Bahar, 2025), but none engages the construct of sustainability consciousness.

Consequently, no review has taken the empirical *relationship* between sustainability consciousness (or its cognates) and student creativity as its unit of analysis that is, how the two constructs are jointly measured, in what direction they are related, and how each is operationalized at the study level. Teacher-education research similarly treats the two agendas in parallel rather than in concert (Ammoneit et al., 2022). This dual gap, a fragmentation of constructs and the absence of an integrative framework, leaves educators and researchers, particularly in science education, without a consolidated evidence base on which to build practice or theory.

Although only eleven studies meet these criteria, their consolidation is precisely what neither parent literature can provide: it is the first synthesis to place the two constructs in a single analytic frame, and it is large enough to reveal a reproducible pattern, a consistent positive association coupled with an unsettled causal direction, while remaining small enough to expose, study by study, the construct fragmentation and the absence of an integrative framework that this review documents. The present study addresses this gap through a systematic review of empirical studies (2015–2026) that measured at least one sustainability consciousness construct and at least one creativity construct as explicit variables in formal secondary-to-tertiary education. Rather than assuming a settled relationship, we map how the relationship has been studied, what it shows, and how the two constructs have been conceptualized, mapping every included study onto the tripartite sustainability-consciousness framework (knowingness, attitudes, and behavior across the environmental, social, and economic dimensions) alongside the type of creativity measure used (Table 5) in order to lay the groundwork for an integrative account relevant to science education. We address three research questions:

1. What are the characteristics of empirical studies examining the relationship between sustainability consciousness and student creativity in terms of research design, measurement instruments, educational level, and geographical distribution?
2. How is the relationship between sustainability consciousness and creativity reported in terms of its direction, strength, and consistency across educational contexts?
3. RQ3. How are sustainability consciousness and creativity conceptualized and operationalized in the existing studies, and what conceptual gaps remain to be addressed by future science-education research?

By answering these questions, the review consolidates a dispersed literature, clarifies what is and is not yet known about the sustainability consciousness–creativity relationship, and identifies the conceptual and methodological foundations needed to advance research and practice in education for sustainability.

Synthesizing the conceptual considerations above, we advance a tentative organizing framework (see Figure 1) that structures the synthesis and to which we return in the Discussion. It treats the sustainability-consciousness–creativity relationship as reciprocal and mechanism-based and is expressed as four propositions. P1 (reciprocity): sustainability consciousness and creativity are positively and bidirectionally related, rather than linked in a single fixed direction. P2 (cognitive mechanism): this relationship is transmitted partly through a cognitive pathway domain knowledge, creative self-efficacy, and creative style (Green & Rizwan, 2024; Suherman & Vidákovich, 2025). P3 (affective mechanism): it is transmitted partly through an affective pathway emotional and eco-emotional engagement (Contreras et al., 2024; Stanley et al., 2021). P4 (moderation): its strength and direction are moderated by educational level, discipline, and culture. A measurement corollary cut across all four: the two constructs should be assessed at commensurate levels, pairing a comprehensive, tripartite operationalization of sustainability consciousness knowingness, attitudes, and behavior across the environmental, social, and economic dimensions (Gericke et al., 2019) with a domain-appropriate creativity measure. We do not test these propositions statistically; rather, we map the existing evidence onto them to establish what is currently supported and where the gaps lie.

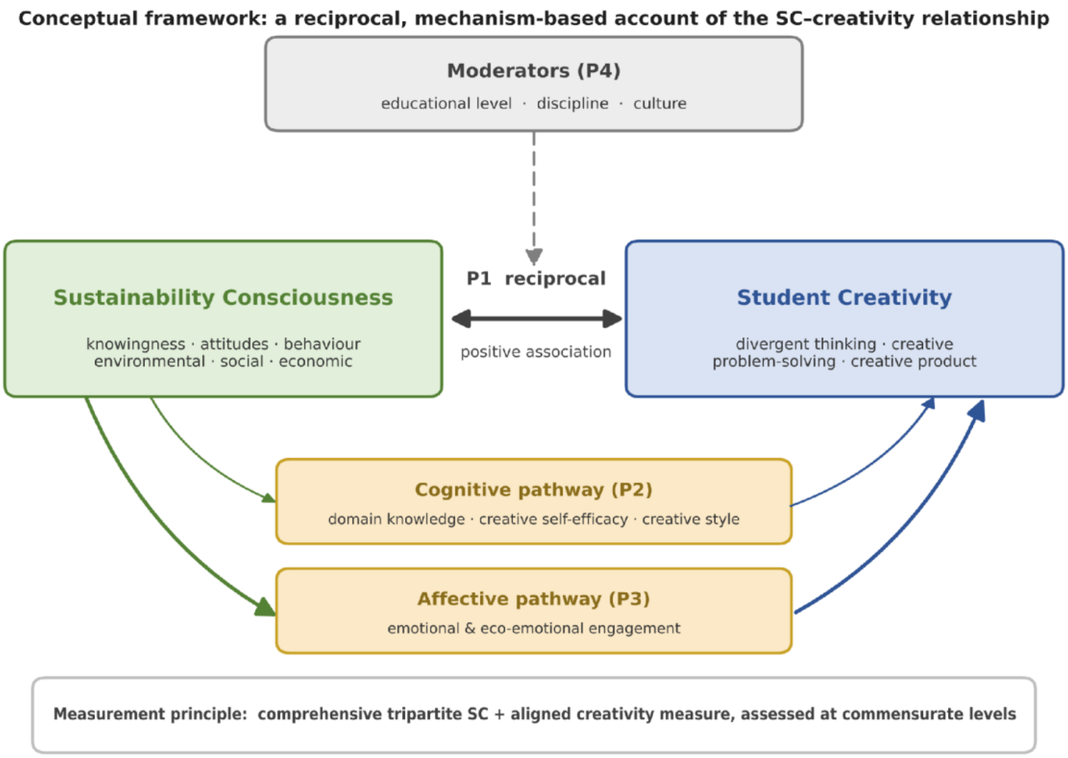

Figure 1 Conceptual framework: a reciprocal, mechanism-based account of the sustainability consciousness–creativity relationship, expressed as four propositions (P1–P4) with a cross-cutting measurement corollary

METHODS

This systematic review was conducted and reported in accordance with the PRISMA 2020 statement (Page et al., 2021); the completed PRISMA 2020 checklist is provided as supplementary material (Appendix A). The review was not prospectively registered (e.g., in PROSPERO) and no separate protocol was published. To mitigate the risk of bias that registration is intended to control, the eligibility framework, search strings, and all screening decisions were specified a priori and applied through a structured screening workbook; the seven inclusion criteria (I1–I7) and the exclusion codes (E1–E4), together with the per-record decisions for all 58 title–abstract records and 26 full-text reports, are provided as Supplementary Material (Appendix B) so that the selection process is fully auditable. Because the eligible studies were heterogeneous in design, instrumentation, and educational context, the evidence was integrated through thematic synthesis (Thomas & Harden, 2008) rather than statistical meta-analysis.

Eligibility Criteria

Studies were eligible if they reported primary empirical research that measured at least one sustainability consciousness (SC) construct and at least one creativity construct as explicit study variables within formal education. The full inclusion and exclusion criteria are presented in Table 1. Two ambiguous cases were resolved a priori: studies reporting the reverse association (creativity → SC) were retained because they inform the directionality question, and SC-cognate constructs (e.g., environmental literacy, ecological awareness) were included only when they operationally captured awareness of sustainability. To guard against construct drift, a cognate label was admitted only if its instrument measured sustainability awareness as an explicit study variable that could be mapped onto at least one facet (knowingness, attitudes, behavior) and dimension (environmental, social, economic) of the tripartite sustainability-consciousness framework Gericke et al., 2019); this mapping is reported for every included study in Table 1.

Studies in which "sustainability" functioned only as a pedagogical framing rather than a measured student construct, or in which the "creativity" side in fact denoted innovation in educational practice rather than student creativity, were excluded at full text (criterion I5). Worked examples of these boundary decisions are listed in Appendix B.

Table 1 inclusion and exclusion criteria

Parameter	Inclusion	Exclusion
Publication type	Peer-reviewed journal article indexed in Scopus or Web of Science	Conceptual paper, editorial, commentary, review, meta-analysis, theoretical paper
Year	2015–2026	Outside 2015–2026
Language	English	Non-English
Population	Students in formal secondary-to-tertiary education; pre-service teachers as learners	Pupils below secondary level; in-service teachers, administrators, or the general public as the main subjects
Constructs	Measures ≥1 SC (or cognate) construct and ≥1 creativity construct as explicit research variables	A construct mentioned only in the background and not measured
Study type	Primary empirical (quantitative, qualitative, mixed methods, action research)	Non-empirical work; full text inaccessible; duplicate record
Setting	Formal education (school, university, structured program)	Organizational, corporate, or non-educational community settings

Information sources and search strategy

Two databases were searched: Scopus and Web of Science (Core Collection). These two indexes were selected because they are the most comprehensive, multidisciplinary, and rigorously curated citation databases, applying explicit quality and selectivity criteria for indexing; together they provide broad and complementary coverage of peer-reviewed educational, psychological, and sustainability research. The databases are most widely used as the backbone of systematic reviews in education for sustainable development. Searches were executed in May–June 2026. The query combined three concept blocks sustainability consciousness, creativity, and the educational population applied to title, abstract, and keyword fields. The complete search strings are reported in Table 2. The exports returned 77 records from Scopus and 49 from Web of Science.

The researchers restricted the search to Scopus and Web of Science and did not search subject-specific databases (e.g., ERIC, PsycINFO) or perform backward–forward citation chasing; relevant studies indexed only elsewhere, or grey literature, may therefore have been missed. The breadth of the three-block query and the use of two complementary multidisciplinary indexes partly offset this risk, but the small final corpus should be read with this boundary in mind.

Table 2 Search Strings by Database (title–abstract–keyword)

Database	Search String
Scopus	TITLE-ABS-KEY(("sustainability consciousness" OR "environmental consciousness" OR "ecoliteracy" OR "sustainability awareness" OR "sustainability literacy" OR "ecological awareness" OR "environmental literacy") AND ("creative thinking" OR "creative product" OR "creativity" OR "creative competence" OR "creative performance" OR "creative ability" OR "creative skill" OR "innovative thinking") AND ("student*" OR "learner*" OR "undergraduate" OR "classroom" OR "education" OR "learning" OR "teaching"))

Web of Science	TS=("sustainability consciousness" OR "environmental consciousness" OR "ecoliteracy" OR "sustainability awareness" OR "sustainability literacy" OR "ecological awareness" OR "environmental literacy") AND TS=("creative thinking" OR "creative product" OR "creativity" OR "creative competence" OR "creative performance" OR "creative ability" OR "creative skill" OR "innovative thinking") AND TS=("student*" OR "learner*" OR "undergraduate" OR "classroom" OR "education" OR "learning" OR "teaching")

Study Selection

After the 126 records were combined, 40 duplicates were removed by matching Digital Object Identifiers and normalized titles, leaving 86 unique records. Automated filtering then removed records published outside 2015–2026 (n = 2), non-article document types (n = 24), and non-English records (n = 2). The remaining 58 records were screened on title and abstract against the eligibility criteria, and 28 were excluded. Of the 30 reports sought for retrieval, 4 could not be accessed. The 26 retrieved reports were assessed in full text, and 15 were excluded, 2 for an out-of-scope educational level and 13 because the two constructs were not both measured as study variables, yielding 11 studies for synthesis. The complete process is shown in Figure 2. Title–abstract screening and full-text screening were performed by two reviewers, who assessed every record against the seven inclusion criteria (I1–I7); a shared decision rule and a set of exclusion codes (E1–E4) were calibrated on a sample of records before independent screening. Disagreements at both stages were resolved through discussion until consensus; a chance-corrected agreement coefficient (e.g., Cohen's κ) was not computed, and reliance on consensus rather than a quantified agreement statistic is acknowledged as a limitation. The 15 reports excluded at full text 2 for an out-of-scope educational level (I4) and 13 because the two constructs were not both measured as study variables (I5) are listed individually with reasons in Appendix B.

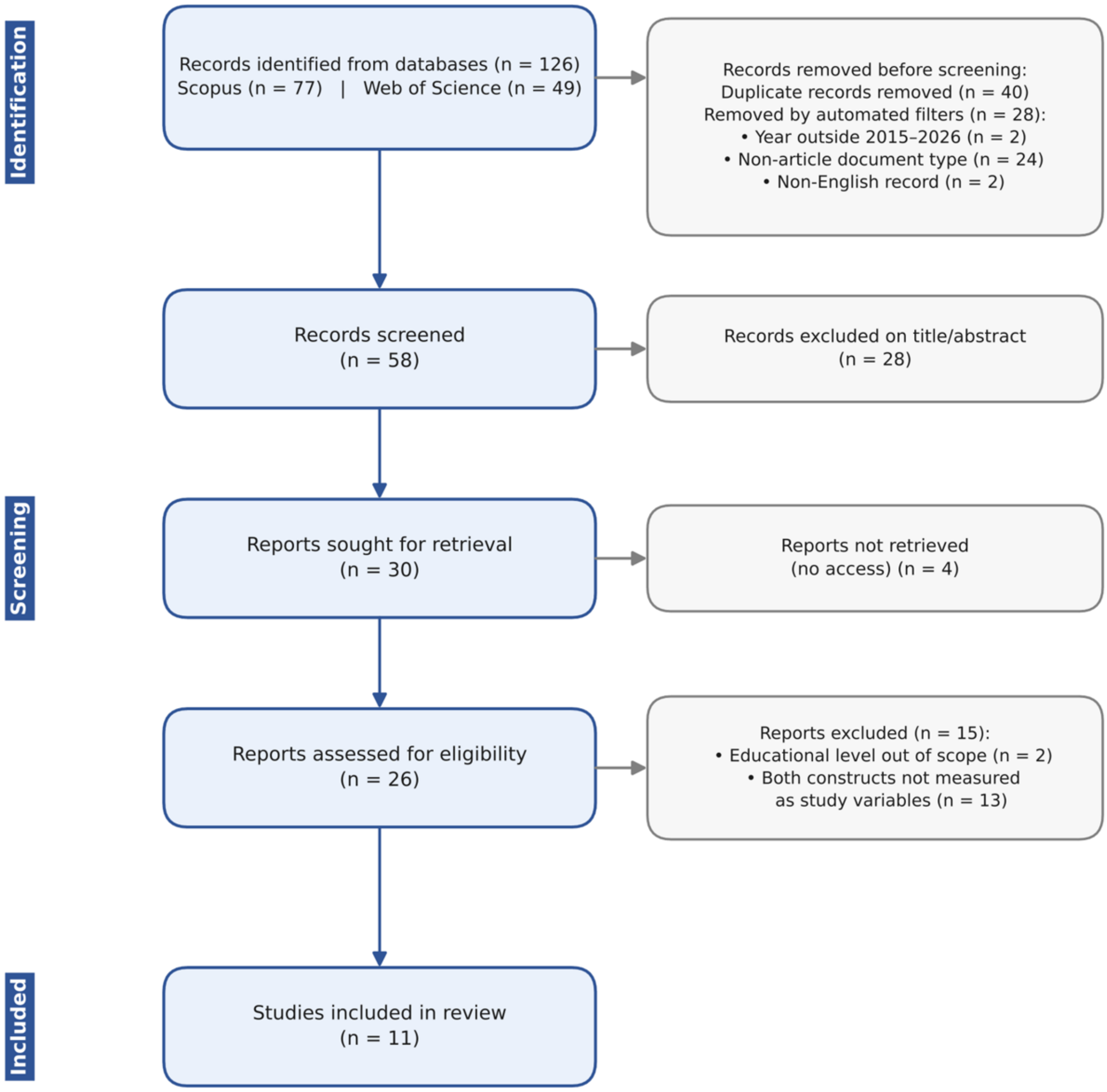

Figure 2 PRISMA 2020 flow diagram of the identification and selection of studies

Data extraction

A structured charting form was used to extract from each study: citation, country, educational level, study design, sample, analytical approach, the SC and creativity constructs (label, conceptual definition, and operationalization/instrument), and the reported relationship (type, direction, effect estimate, key finding, and any mediators or moderators). One reviewer extracted the data and a second independently checked them against the full texts; discrepancies were resolved by discussion to consensus.

Quality appraisal

Methodological quality was appraised with the Mixed Methods Appraisal Tool (MMAT) version 2018 (Hong et al., 2018), which enables the concurrent appraisal of qualitative, quantitative, and mixed methods designs. Each study was rated against the two screening items and the five category-specific criteria. Consistent with the developers' guidance, ratings were retained per criterion rather than collapsed into a single score, and quality was used to interpret not to exclude evidence.

Data synthesis

Following Thomas & Harden (2008), synthesis proceeded in three stages: line-by-line coding of findings relevant to the research questions, organization of codes into descriptive themes, and development of analytical themes. The themes were structured to address the study characteristics (RQ1), the SC–creativity relationship (RQ2), and the conceptualization and operationalization of both constructs together with the remaining gaps (RQ3).

RESULT AND DISCUSSION

RESULT

The searches and screening yielded 11 studies for synthesis. Their general characteristics are summarized in Table 3, and a descriptive overview is provided in Figure 3. The studies were recent: one was published in 2021, two in 2023, one in 2024, and seven in 2025 (Figure 3a), confirming that empirical interest in the sustainability consciousness (SC)–creativity nexus is a very recent phenomenon. Data were collected in five countries, with Indonesia contributing the largest share (n = 5), followed by Spain and Taiwan (n = 2 each) and Thailand and Saudi Arabia (n = 1 each) (Figure 3b). Secondary education was slightly more represented (n = 6) than tertiary education (n = 5); the tertiary studies included two conducted with pre-service teachers as learners (Figure 3c). Methodologically, the corpus combined four mixed-methods studies, three correlational/structural-equation-modelling (SEM) studies, three quasi-experiments, and one development/practicality study (Figure 3d). Sample sizes ranged from 7 pre-service teachers in a qualitative case study (Echegoyen-Sanz et al., 2024) to 869 secondary students in a cross-sectional SEM study (Suherman & Vidákovich, 2025).

Table 3 Characteristics of the included studies (n = 11)

ID	Study	Country	Level	Sample	Design & analysis
S1	Winarto et al., (2025)	Indonesia	Secondary (Gr. 7)	32	Quasi-experiment (one-group pre–post); paired *t*, Wilcoxon, effect size
S2	Chen & Chang (2024)	Thailand	Tertiary (master's)	75	Mixed methods (non-equivalent quasi-experiment + interviews); *t*, regression, thematic coding
S3	Patonah et al., (2025)	Indonesia	Secondary (vocational, Gr. 10)	30	Development/practicality (ADDIE); descriptive + observation
S4	Sigit et al., (2023)	Indonesia	Secondary (Gr. 11)	281	Correlational (cross-sectional); Pearson, regression
S5	Abdullateef (2024)	Saudi Arabia	Tertiary (undergraduate)	49	Quasi-experiment (control–experimental); pre–post comparison
S6	Echegoyen Sanz & Martín-Ezpeleta (2021)	Spain	Tertiary (pre-service teachers)	47	Mixed methods (qualitative product analysis + validated scale)
S7	Koong Lin et al., (2025)	Taiwan	Secondary (Gr. 12)	57	Mixed methods (grounded theory + pre–post); coding (κ = 0.82), *t*, Cohen's *d*

S8	Hasibuan et al., (2025)	Indonesia	Tertiary (university)	45; 60	Correlational–predictive (two samples); Pearson/Spearman, multiple regression
S9	Echegoyen-Sanz et al., (2024)	Spain	Tertiary (pre-service teachers)	176	Mixed methods (product analysis + two validated questionnaires)
S10	Suherman & Vidákovich (2025)	Indonesia	Secondary (11–15 yrs)	869	Cross-sectional SEM (PLS); mediation
S11	Liao et al., (2025)	Taiwan	Secondary (vocational, Yr. 2)	64	Quasi-experiment (control–experimental); pre–post *t*

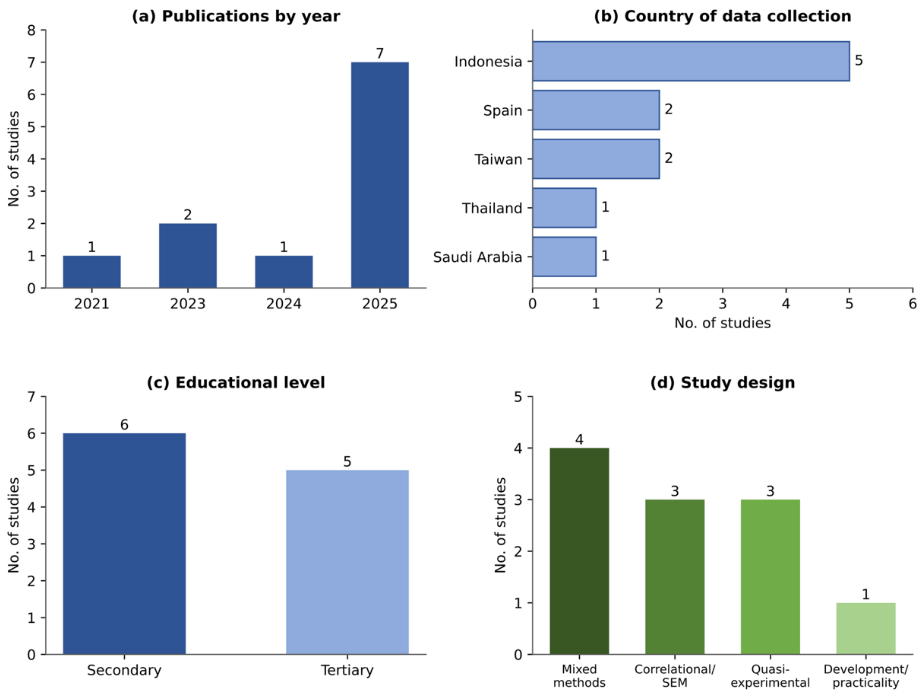

Figure 3. Descriptive characteristics of the included studies: (a) publications by year, (b) country of data collection, (c) educational level, (d) study design

Characteristics of the included studies

The corpus was small, geographically concentrated, and methodologically heterogeneous. Almost half of the studies originated from a single country (Indonesia), and the remainder were dispersed across four countries on three continents, with no contributions from North America, Africa, or Oceania. The constructs were examined across a wide range of subject contexts STEM and science education (Patonah et al., 2025; Sigit et al., 2023; Winarto et al., 2025), mathematics (Suherman & Vidákovich, 2025), chemistry, language and writing (Abdullateef, 2024), art and design (Liao et al., 2025), music, and management education (Chen & Chang, 2024) indicating that the relationship is being probed in disconnected disciplinary silos rather than within a cumulative programme of research.

The designs are clustered into two broad families. The first comprised genuinely *relational* designs three cross-sectional correlational/SEM studies (Hasibuan et al., 2025; Sigit et al., 2023; Suherman & Vidákovich, 2025) that modelled the association between SC and creativity directly. The second comprised *intervention or developmental* designs three quasi-experiments

(Abdullateef, 2024; Liao et al., 2025; Winarto et al., 2025) and one practicality study (Patonah et al., 2025) in which both constructs were measured as parallel outcomes of a pedagogical treatment. The four mixed-methods studies (Chen & Chang, 2024; Echegoyen Sanz & Martín-Ezpeleta, 2021; Echegoyen-Sanz et al., 2024; Koong Lin et al., 2025) bridged these families, pairing a quantitative measure of one or both constructs with qualitative analysis of student products or discourse. This distribution has a direct bearing on RQ2: only three of eleven studies were designed to estimate the SC–creativity association as such, whereas the majority inferred it indirectly from co-occurring gains.

Sample sizes were generally modest: five studies were based on fewer than 60 participants (Abdullateef, 2024; Echegoyen Sanz & Martín-Ezpeleta, 2021; Koong Lin et al., 2025; Patonah et al., 2025; Winarto et al., 2025), and only two exceeded 200 (Sigit et al., 2023; Suherman & Vidákovich, 2025). The instructional approaches through which the constructs were studied were equally varied. The intervention and mixed-methods studies deployed game-based STEM learning for sustainable development (Winarto et al., 2025), STEAM- and project-based learning aligned to the Sustainable Development Goals (Patonah et al., 2025), eco-composition writing (Abdullateef, 2024), virtual-reality art education scaffolded by a creative-problem-solving model (Liao et al., 2025), ecofeminist film design (Echegoyen Sanz & Martín-Ezpeleta, 2021), transdisciplinary digital storytelling (Echegoyen-Sanz et al., 2024), AI-mediated environmental composition (Koong Lin et al., 2025), and explicit creative-problem-solving training (Chen & Chang, 2024). No two interventions shared the same pedagogical model, and none was replicated, so any inference about "what works" rests on single, unreplicated implementations.

Methodological quality

The methodological quality of the corpus, appraised with the MMAT 2018 (Hong et al., 2018), was moderate to good (Figure 4). Consistent with MMAT guidance, criteria were retained individually rather than summed into an overall score; the per-criterion appraisal for every study is reported in Appendix C and visualized in Figure 4. All studies had clear research questions and data able to address them, and all reported appropriate analytical procedures (criterion 5). The decisive pattern is concentrated in a single criterion: in ten of the eleven studies it could not be confirmed that confounders were accounted for (quantitative and mixed designs) or that non-response/observer bias was minimised (criterion 4), reflecting non-randomised allocation and small single-class samples in the quasi-experiments and the absence of controls for third variables in the cross-sectional studies. Measurement quality (criterion 3) was "can't tell" for the practicality study (Patonah et al., 2025), whose constructs were captured through observation rubrics rather than validated scales, and two ecological-literacy subscales showed low internal consistency $\alpha = 0.45–0.59$ (Sigit et al., 2023). These limitations do not invalidate the studies, but they bound interpretation: because the weakest criterion is precisely the control of confounding, the consistently positive associations reported below are best read as descriptive co-occurrence rather than as bias-controlled estimates of effect. Consistent with MMAT guidance, no study was excluded on quality grounds.

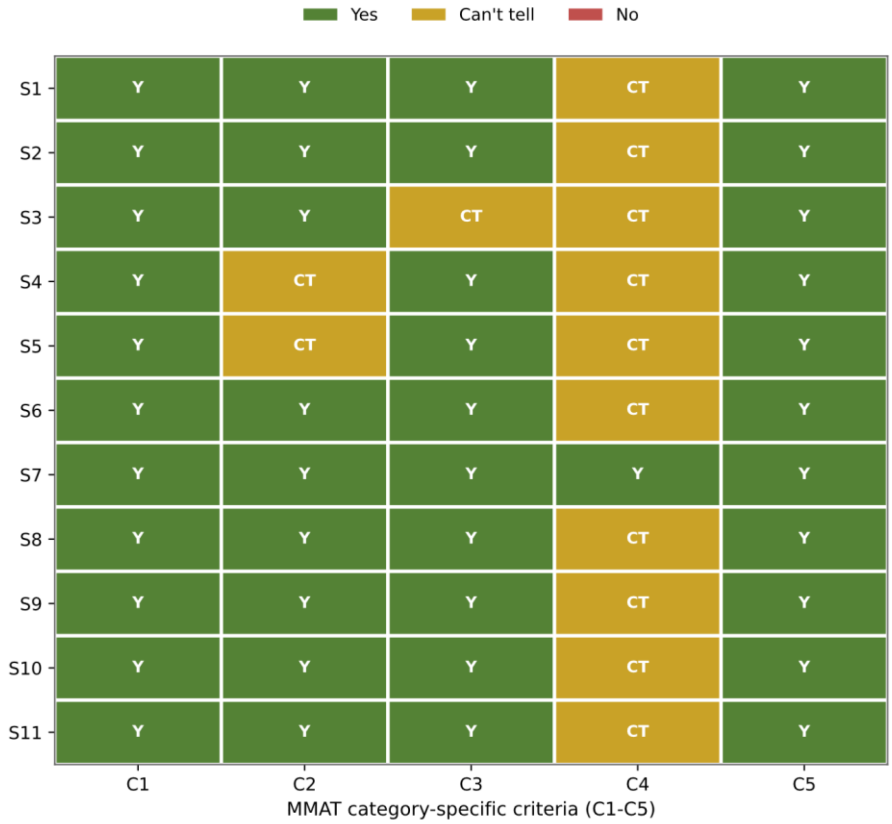

Figure 4 Methodological quality of the included studies appraised with the MMAT 2018 (heatmap of the five category-specific criteria, C1–C5)

The relationship between sustainability consciousness and creativity (RQ2)

Across the corpus, the reported association between SC and creativity was consistently positive wherever it was assessed: ten of the eleven studies reported a significant or consistently positive relationship, and only one reported a mixed result. This positive valence should, however, be read against the design distribution reported above: only three studies (S4, S8, S10) modelled the SC–creativity association directly, whereas the remainder inferred it from co-occurring gains under an intervention. The studies differed, however, in the *direction* they attributed to the association, which allowed them to be mapped onto three categories (Table 4; Figure 5): SC predicting creativity, creativity predicting SC, and the parallel co-development of both constructs under a shared intervention.

Table 4 Constructs, operationalisation, and the reported SC–creativity relationship

ID Study	SC construct (instrument)	Creativity construct (instrument)	Relationship type & direction	Reported effect / key finding
S4	Ecological literacy (Likert questionnaire + multiple-choice test)	Creative thinking — FFOE (essay test)	Relational; SC → creativity	Significant positive correlation between ecological literacy and creative thinking
S10	Environmental literacy (6-item scale)	Mathematical creative thinking; creative style;	Relational (SEM, mediation);	Environmental literacy positively predicts MCT and mediates the effects

		creative self-efficacy (scales)	SC → creativity	of self-efficacy and attitudes on MCT
S2	Sustainability awareness (SSRQ; α = .92)	Creative problem-solving (CPSQ)	Intervention + relational; creativity → SC	CPS training significantly raised both CPS skills and sustainability awareness; CPS predicted sustainability awareness
S7	Environmental consciousness (Environmental Awareness Scale; α = .89)	AI-mediated creative composition (coding, κ = .82; rubric)	Relational (intervention) ; creativity → SC	Creative process linked to increased environmental consciousness, $t(56) = 8.34$, $p < .001$, $d = 1.11$
S8	Digital ecoliteracy (20-item scale; α = .89)	Creative thinking (Torrance-based scale; α = .84)	Relational (predictive); creativity → SC	Creative thinking predicted digital ecoliteracy across two samples (β = .39–.59; model R^2 = .72–.75)
S1	Environmental literacy (questionnaire)	Creative thinking (test)	Intervention; co-development	Game-based STEM-EfSD raised creative thinking (Wilcoxon $p < .001$) and environmental literacy ($p = .013$)
S3	Environmental literacy (integrated rubric)	Creative thinking — TTCT (observation rubric)	Intervention; co-development	STEAM–SDGs model rated highly practical; creative-thinking indicators 73–90% (high)
S5	Sustainability awareness (pre–post task)	Creative thinking — FOFE (TTCT)	Intervention; co-development	Eco-composition group exceeded controls on all FOFE dimensions; motivation–writing–awareness linked
S6	Sustainability attitudes (validated scale)	Creativity (qualitative product analysis)	Co-occurrence (intervention)	High sustainability attitudes (>4/5) alongside diverse creative film proposals
S9	Sustainability attitudes (two validated questionnaires)	Creativity (digital-story product analysis)	Co-occurrence (intervention)	Very high sustainability attitudes across all dimensions alongside creative digital storytelling

S11	Environmental literacy (formative assessment)	Creativity in public-art creation (teacher + self-assessment; VR tool)	Intervention; co-development	VR + CPS significantly improved creative engagement and creation; environmental-literacy gain not significant

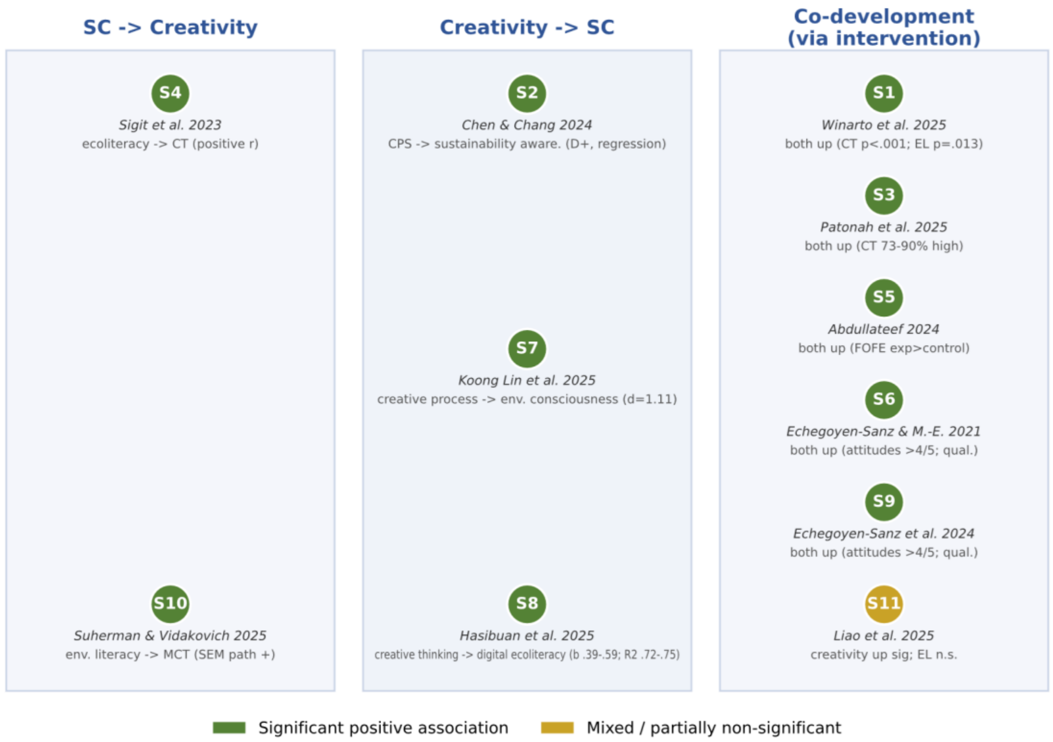

Figure 5. Evidence map of the sustainability consciousness–creativity relationship, with studies grouped by direction (SC → creativity; creativity → SC; co-development) and coloured by significance

Direction 1: Sustainability consciousness predicting creativity

Two studies positioned SC as an antecedent of creativity. Sigit et al. (2023) surveyed 281 grade-11 science students across three Indonesian regions, measuring ecological literacy with a 24-item Likert questionnaire plus a knowledge test and creative thinking with a four-dimension essay test (fluency, flexibility, originality, elaboration); they reported a significant positive relationship and concluded that ecoliteracy "contributes" to creative thinking a directional reading grounded in theory rather than in temporal precedence. (Suherman & Vidákovich, 2025) provided the strongest evidence in this direction. Using a PLS-SEM model of 869 secondary students and an unusually rich creativity specification (mathematical creative thinking, creative style, and creative self-efficacy), they found that environmental literacy not only predicted mathematical creative thinking directly but also functioned, alongside creative style, as a mediator transmitting the effects of creative self-efficacy and attitudes toward mathematics onto creative performance. Together these studies suggest that an ecological knowledge base and value orientation can scaffold domain-specific creative cognition, although both are cross-sectional and therefore cannot establish that SC precedes creativity in time.

Direction 2: Creativity predicting sustainability consciousness

Three studies positioned creativity as the antecedent. Hasibuan et al. (2025) offered the most rigorous test, replicating a regression model across two independent university samples (N = 45 and N = 60): creative thinking, together with critical thinking, significantly predicted digital ecoliteracy, with the two cognitive predictors jointly explaining 72–75% of the variance (β = .39–.59 for creative thinking). Koong Lin et al. (2025) reported a large effect: among grade-12 students engaged in AI-mediated environmental composition, the creative process was associated with a substantial pre–post increase in environmental consciousness ($t(56) = 8.34$, $p < .001$, $d = 1.11$), with emotional scaffolding acting as a mediator. Chen & Chang (2024) showed, in a mixed-methods quasi-experiment with master's students, that creative-problem-solving training raised sustainability awareness and that CPS skills predicted that awareness, with the qualitative interview themes converging on the same conclusion. This body of evidence indicates that engaging students in creative production can deepen their awareness of, and commitment to, sustainability.

Direction 3: Parallel co-development under a shared intervention

The largest group six studies did not test a directional association but instead measured SC and creativity as parallel outcomes of a single pedagogical intervention, generally reporting that both improved together. Quasi-experimental and developmental studies showed concurrent gains in creative thinking and environmental literacy through game-based STEM learning (Winarto et al., 2025), a STEAM–SDGs project model (Patonah et al., 2025), and eco-composition writing (Abdullateef, 2024), the last reporting that the experimental group surpassed controls on every Torrance dimension. Two mixed-methods studies with pre-service teachers documented high sustainability attitudes alongside creative production ecofeminist film proposals (Echegoyen Sanz & Martín-Ezpeleta, 2021) and digital storytelling (Echegoyen-Sanz et al., 2024). The single discrepant case was Liao et al. (2025), a virtual-reality, creative-problem-solving art curriculum significantly enhanced students' creative engagement and creation, but the accompanying gain in environmental-literacy knowledge did not reach statistical significance illustrating that the two constructs do not invariably move together.

Mediators and moderators

A small number of studies illuminated the mechanisms and boundary conditions of the association. Suherman & Vidákovich (2025) modelled environmental literacy and creative style as mediators, showing that the effects of creative self-efficacy and attitudes toward mathematics on mathematical creative thinking operated partly through them evidence of an indirect, cognitive pathway. Koong Lin et al. (2025) identified emotional scaffolding as a mediator between AI-supported creative composition and environmental consciousness, pointing instead to an affective pathway. Demographic moderators were examined only sparingly and inconsistently, Sigit et al. (2023) reported higher ecological-literacy and creative-thinking scores among female students, whereas Echegoyen Sanz & Martín-Ezpeleta (2021) found no gender differences in sustainability attitudes. No study tested educational level, discipline, or culture as a moderator, even though the corpus spanned all three leaving the conditions under which the SC–creativity link strengthens or weakens essentially unexplored.

Consistency of findings

The direction of the association was therefore inconsistent across the corpus, but its valence was not: wherever a relationship was detected, it was positive, and effect estimates where reported ranged from moderate correlations Sigit et al. (2023) to large effects ($d = 1.11$) (Koong Lin et al., 2025) and high explained variance (R^2 up to .75) (Hasibuan et al., 2025). This convergence is, however, tempered by the predominance of cross-sectional and non-randomised designs (Section 3.2), the reliance on co-occurrence rather than directional modelling in over half the corpus, and the absence of any longitudinal or experimental study capable of establishing causal order. The positivity of the evidence should also be read against the small number of studies, their concentration in a handful of settings, and the possibility that null or negative findings remain unpublished at a risk that the single mixed result (Liao et al., 2025) makes tangible. The corpus thus supports a descriptive observation that sustainability consciousness and creativity tend to co-occur and move together but it does not warrant a claim about which drives which, or under what conditions; the predominance of cross-sectional and co-development designs, the reliance on co-occurrence rather than directional modelling in over half the corpus, and the unconfirmed control of confounders (Appendix C) place clear limits on any causal reading.

Conceptualisation and operationalisation of the constructs (RQ3)

The synthesis revealed pronounced conceptual fragmentation on the sustainability side. The eleven studies operationalised the sustainability construct under at least six different labels: environmental literacy (Liao et al., 2025; Patonah et al., 2025; Suherman & Vidákovich, 2025; Winarto et al., 2025), ecological literacy (Sigit et al., 2023), digital ecoliteracy (Hasibuan et al., 2025), sustainability awareness (Abdullateef, 2024; Chen & Chang, 2024), sustainability attitudes (Echegoyen Sanz & Martín-Ezpeleta, 2021; Echegoyen-Sanz et al., 2024), and environmental consciousness (Koong Lin et al., 2025). Critically, none of the studies operationalised the full, tripartite *sustainability consciousness* construct knowingness, attitudes, and behaviour spanning the environmental, social, and economic dimensions of sustainability (Gericke et al., 2019). Most instruments privileged the environmental dimension and the cognitive (knowledge/literacy) or affective (attitude/awareness) facets, while the social and economic dimensions and the behavioural facet were largely absent. Table 5 maps every included study onto the tripartite framework (facets × dimensions) together with its creativity measure, making this pattern visible study by study, the environmental dimension is covered by all eleven studies, the social and economic dimensions by only a few (S2, S6, S7, S9), and no single study spans all three facets across all three dimensions. The instruments were correspondingly diverse and mostly locally adapted self-report scales or tests, with only a minority drawing on established, cross-context tools.

Where standardised instruments were used, they were drawn from disparate traditions for example, the Sustainable Social Responsibility Questionnaire (Chen & Chang, 2024), a 20-item Digital Ecoliteracy Scale (Hasibuan et al., 2025), and an Environmental Awareness Scale (Koong Lin et al., 2025) none of which is interchangeable with another. Although several instruments did include a behavioural component sustainable consumer behaviour (Chen & Chang, 2024), pro-environmental behaviour (Patonah et al., 2025), practical competence (Sigit et al., 2023), and environmental advocacy (Koong Lin et al., 2025) the behavioural facet was captured unevenly and often weakly: through brief or low-reliability self-report subscales ($\alpha = 0.45–0.59$) (Sigit et al., 2023), behavioural proxies such as motivation/self-efficacy (Winarto et al., 2025) or skills (Liao et al., 2025), or project artefacts rather than validated behaviour measures. Knowingness and attitudes were measured more consistently than behaviour, and no single study assessed all three facets across all three sustainability dimensions. Several scales were locally developed or translated and adapted for a single study, and reliability evidence was uneven, further constraining cross-study comparability.

The creativity construct was comparatively more coherent but still varied in grain. A majority operationalised creativity as divergent or creative thinking within the Torrance tradition, measured by tests or rubrics indexing fluency, flexibility, originality, and elaboration (Abdullateef, 2024; Hasibuan et al., 2025; Patonah et al., 2025; Sigit et al., 2023; Winarto et al., 2025). Others used domain-specific or product-based formulations: creative problem-solving (Chen & Chang, 2024; Liao et al., 2025), mathematical creative thinking with creative style and self-efficacy (Suherman & Vidákovich, 2025), and the qualitative analysis of creative products or processes (Echegoyen Sanz & Martín-Ezpeleta, 2021; Echegoyen-Sanz et al., 2024; Koong Lin et al., 2025).

A recurring asymmetry compounded this fragmentation, SC was typically assessed through self-reported awareness or attitude scales, whereas creativity was more often assessed through performance tests or product ratings. Few studies aligned the two constructs at the same level of measurement, and none articulated an integrative theoretical model specifying *how* sustainability consciousness and creativity are linked. Two conceptual gaps therefore stand out from the evidence: the field lacks a shared, comprehensive operationalisation of sustainability consciousness (a fragmentation gap), and it lacks an integrative framework relating the two constructs (a framework gap) gaps that the present review's research questions were designed to expose and that the Discussion addresses.

Table 5 Mapping of sustainability-consciousness facets and dimensions and the type of creativity measure (n = 11)

ID	Facets K·A·B	Dimensions Env·Soc·Econ	Creativity measure (type)	SC instrument (brief)
S1	● · ● · ◐	● · ○ · ○	Divergent thinking, FFOE (test)	Environmental Literacy Questionnaire (knowledge/values/attitudes/behavior)
S2	● · ● · ●	● · ● · ◐	Creative problem-solving (CPSQ)	SSRQ: env. concern + sustainable knowledge + consumer behaviour
S3	● · ● · ●	● · ○ · ○	Divergent thinking, TTCT (observation rubric)	MSELS-based rubric: knowledge/attitude/pro-env behaviour
S4	● · ● · ◐	● · ○ · ○	Divergent thinking, FFOE (essay test)	Ecological literacy: MC knowledge test + Likert (caring; practical competence); low subscale α
S5	○ · ◐ · ◐	◐ · ◐ · ○	Divergent thinking, TTCT/FOFE	No validated SC scale; sustainability = writing-task content + engagement
S6	○ · ● · ○	● · ● · ●	Creativity (qualitative film product)	Attitudes toward SD: env/economy/society
S7	● · ● · ●	● · ● · ○	Creative composition (coding κ=.82 + rubric)	Environmental Awareness Scale (α .89) + advocacy follow-up
S8	● · ○ · ◐	● · ○ · ○	Divergent thinking (Torrance scale, α .84)	Digital ecoliteracy (20-item): Access/Evaluate/Apply
S9	○ · ● · ○	● · ● · ●	Creativity (qualitative digital-story product)	Attitudes toward SD: env α.854/econ .837/society .767
S10	◐ · ○ · ○	● · ○ · ○	MCT + creative style + creative self-efficacy	Environmental literacy (6-item), knowledge/awareness-oriented
S11	● · ● · ◐	● · ○ · ○	Public-art creation (rubric + self/teacher; VR)	Environmental literacy pre/post: knowledge/skills/attitude

Legend: ● measured explicitly · ◐ partial/proxy/low-reliability · ○ not measured/not reported.
Facets = Knowingness·Attitude·Behaviour;
Dimensions = Environmental·Social·Economic.
Coding verified from the primary studies' measurement sections.

DISCUSSION

This review set out to map how the empirical literature characterises, relates, and conceptualises sustainability consciousness (SC) and student creativity in formal education. Three findings stand out: the reported association is consistently positive but directionally ambiguous; the SC construct is operationalised in a fragmented way; and no study advances an integrative model linking the two constructs. We discuss each against the wider literature and draw implications for science education.

A consistent but under-theorized positive association

The most consistent pattern in the corpus is that SC and creativity tend to rise together. This convergence aligns with a growing body of work that treats creativity not as an ornament of learning but as a competence for sustainability. (Mróz & Ocetkiewicz, 2021) similarly position students' creativity as something to be deliberately cultivated for sustainable development, and European competence frameworks now embed creative, futures-oriented capacities within sustainability competence itself (Martín-Ramos et al., 2025; Toma et al., 2024), paralleling the action-oriented conception of SC captured by instruments such as the ACiSD-Q (Sass et al., 2021). Our synthesis is therefore consistent with a relationship that policy and theory have largely assumed, while showing that the primary evidence for it remains largely descriptive.

What the corpus cannot yet settle is *direction*. The two studies that modelled SC as an antecedent (Sigit et al., 2023; Suherman & Vidákovich, 2025) and the three that modelled creativity as an antecedent (Chen & Chang, 2024; Hasibuan et al., 2025; Koong Lin et al., 2025) are equally plausible, and both readings have theoretical support. A creativity-to-SC pathway is consistent with evidence that divergent and creative-problem-solving capacities underpin the generation of solutions to ill-structured, real-world problems (Khalid et al., 2020; Molnár & Pásztor, 2025; Sadak et al., 2022), students who can reframe problems may more readily translate environmental awareness into novel responses. An SC-to-creativity pathway is equally defensible, since an ecological knowledge base can supply the rich, personally meaningful content on which domain-specific creativity draws (Suherman & Vidákovich, 2025; Wu et al., 2025). The mediators reported in the corpus map onto two complementary mechanisms: a cognitive route operating through creative style and self-efficacy (Suherman & Vidákovich, 2025) consistent with evidence that creative self-efficacy can be deliberately nurtured (Green & Rizwan, 2024) and an affective route operating through emotional engagement (Koong Lin et al., 2025), which resonates with findings that eco-emotions such as eco-anger and eco-anxiety can mobilise pro-environmental action (Contreras et al., 2024; Stanley et al., 2021). The most parsimonious interpretation is therefore reciprocal rather than unidirectional: SC and creativity plausibly reinforce one another through intertwined cognitive and affective channels. The predominance of cross-sectional and co-development designs, however, means this remains a hypothesis the field has not yet tested with longitudinal or experimental data.

Fragmentation in conceptualising sustainability consciousness

The second contribution of this review is to expose how unevenly the sustainability construct is operationalised. Across the eleven studies, the construct appeared under at least six labels and was measured mostly through locally adapted environmental- or ecological-literacy proxies that privilege the environmental dimension and the cognitive–affective facets, while the social and economic dimensions and the behavioural facet were largely absent. This is a striking gap, because a validated, tripartite operationalisation of *sustainability consciousness* knowingness, attitudes, and behaviour across the environmental, social, and economic dimensions has been available and repeatedly applied with students elsewhere (Arantes & Sousa, 2025; Eraslan et al., 2024; Gericke et al., 2019; Ovais, 2023). None of the studies that explicitly examined creativity adopted this integrative instrument; conversely, the SC-measurement literature rarely incorporates creativity. The two literatures, in other words, have developed in parallel without meeting.

A related asymmetry concerns measurement level. SC was typically assessed through self-reported awareness or attitude scales, whereas creativity was assessed through performance tests or product ratings an imbalance that complicates the interpretation of any reported association and may inflate or attenuate it unpredictably. The creativity side was comparatively coherent, dominated by the Torrance tradition of divergent thinking, yet even here the field continues to debate how divergent thinking should be scored and operationalised (Ding et al., 2024; Shaw, 2021), and structured models can measurably enhance creative-thinking outcomes (Saeed & Ramdane, 2022). The methodological appraisal reinforces this caution: the recurring inability to confirm control of confounders, together with occasionally weak reliability, means that even the consistently positive valence of the evidence should be read as suggestive rather than definitive.

Toward an integrative framework and implications for science education

Taken together, the two gaps point to the same need: an integrative framework that specifies *how* sustainability consciousness and creativity are linked, measured at commensurate levels, and cultivated together. Such a framework introduced as Figure 1 would treat the relationship as reciprocal and mechanism-based, linking SC and creativity through cognitive (knowledge, creative self-efficacy, creative style) and affective (emotional engagement) pathways and would pair a comprehensive SC instrument (Gericke et al., 2019) with a domain-appropriate creativity measure within a single design. Crucially, it would also align the two constructs at a common level of measurement, so that the behavioural facet of SC (Eraslan et al., 2024; Sass et al., 2021) is assessed with the same rigour as creative performance, rather than the present mismatch between self-reported awareness and performance-based creativity. Anticipatory and futures-oriented thinking, increasingly framed as a sustainability competence in its own right (Mróz & Ocetkiewicz, 2024), offers one concrete bridging construct through which the cognitive pathway could be specified and tested. This responds directly to the fragmentation the review documents and offers a testable structure for the longitudinal and experimental studies the field currently lacks.

For science education specifically, the framework also specifies how to design and assess both capacities. As a worked example, a project- or STEAM-based unit can be anchored in a local socio-ecological problem (e.g., waste, water, or energy) in which students produce a creative artefact and an actionable sustainability response mirroring the eco-composition (Abdullateef, 2024), STEAM–SDGs (Patonah et al., 2025), digital-storytelling (Echegoyen-Sanz et al., 2024), and AI-mediated composition (Koong Lin et al., 2025) designs in the corpus. Assessment should be dual and commensurate: creativity through a product or divergent-thinking rubric (fluency, flexibility, originality, elaboration), and sustainability consciousness through indicators spanning the three facets knowingness (accuracy of sustainability concepts), attitudes (concern and valuing), and behaviour (the quality and, where feasible, the enactment of the proposed action). Crucially, teachers can gauge behavioural change not only through self-report but through artefacts and follow-up documenting whether students enact or sustain pro-environmental actions after the unit, as in the three-month advocacy follow-up reported by Koong Lin et al. (2025). Embedding creative-problem-solving routines in authentic environmental tasks (Xiong & Ren, 2025) and preparing teachers to teach and assess both capacities together (Ammoneit et al., 2022) are the most direct levers for enacting the framework.

The corpus suggests that the two constructs are most readily co-developed through active, integrative pedagogies. Project- and STEAM-based designs, design thinking, and arts- and drama-based approaches have each been shown to advance creative and sustainability-related outcomes (Bernert et al., 2022; Fries, 2025; Karakuyu & Karafil, 2026; Niu & Cheng, 2022; Vasilopoulos & Dumontheil, 2025; Wu et al., 2025), and creative-problem-solving routines embedded in authentic environmental tasks appear especially promising for science classrooms (Xiong & Ren, 2025). Because pre-service and in-service teachers shape whether such pedagogies are enacted, building their combined creativity- and sustainability-teaching competence is a logical leverage point (Ammoneit et al., 2022; Mróz & Ocetkiewicz, 2024). At the same time, the review exposes a structural limitation of the evidence base: it is small, recent, and geographically narrow, with Indonesia heavily over-represented and entire regions absent. This concentration mirrors broader concerns about the uneven global distribution of sustainability-education research (Ameer & Ghannam, 2025; Hu & Mou, 2025; Işıkgöz & Öztunç, 2026) and limits the cultural generalisability of current claims.

In sum, literature consistently indicates that sustainability consciousness and student creativity tend to move together, but being largely descriptive, cross-sectional, and limited in its control of confounders it does not establish why, in which direction, or under what conditions. Translating this framework into research yields a concrete agenda. To test P1, longitudinal and cross-lagged panel designs are needed to establish temporal precedence and reciprocity, which the present cross-sectional corpus cannot. To test P2 and P3, experimental and mixed-methods explanatory designs with measured mediators experimental- or moderated-mediation models should determine whether the cognitive and affective pathways operate independently or jointly; anticipatory and futures-oriented thinking offers one concrete cognitive mediator to specify and model (Mróz & Ocetkiewicz, 2024). To test P4, multi-group and cross-context comparative designs should sample across educational levels and disciplines and, critically, across the under-represented regions absent here (North America, Africa, Oceania). Across all designs, minimum reporting standards should require a comprehensive sustainability-consciousness instrument (e.g., the SCQ; Gericke et al., 2019) measured across all three facets and dimensions, a validated creativity measure aligned at the same level of assessment, and full per-subscale reliability reporting directly addressing the construct fragmentation and measurement mismatch documented in this review.

CONCLUSION

This systematic review mapped how empirical studies characterise, relate, and conceptualise sustainability consciousness and student creativity in formal education. Across the eleven included studies, the two constructs were consistently and positively associated wherever the relationship was assessed, wherever a relationship was detected it was positive, with effects ranging from moderate correlations to large gains, although only three studies modelled the association directly. Yet the direction of that association was not settled some studies positioned sustainability consciousness as an antecedent of creativity, others reversed the order, and most simply observed the two developing together under a shared pedagogical intervention. This convergence, however, rests on fragmented foundations. The sustainability construct was operationalised inconsistently as environmental literacy, ecological literacy, sustainability awareness, or attitudes and not a single study employed the full, validated sustainability-consciousness construct spanning the environmental, social, and economic dimensions. The behavioural facet was rarely measured, the two constructs were assessed at mismatched levels, and the dominance of cross-sectional and co-development designs precludes any claim about causal order. This fragmentation is at once a limitation of the evidence base and a central finding of the review. Advancing the field therefore requires an integrative, mechanism-based framework. To that end, this review advances one explicitly (Figure 1), a reciprocal, mechanism-based account of the sustainability-consciousness–creativity relationship, expressed as four testable propositions a positive, bidirectional association (P1) transmitted through cognitive (P2) and affective (P3) pathways and moderated by educational level, discipline, and culture (P4). Realising it will require pairing a comprehensive, tripartite sustainability-consciousness instrument with a domain-appropriate creativity measure, aligned at a common level of measurement, and testing the propositions through longitudinal, cross-lagged, and experimental-mediation designs across under-represented regions. For science education specifically, the evidence suggests that active, integrative pedagogies project- and STEAM-based learning, design thinking, and arts-based approaches together with the deliberate preparation of teachers, offer the most promising route to cultivating sustainability consciousness and creativity in concert rather than in isolation.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

REFERENCES

Abdullateef, S. T. (2024). Eco-composition: fostering sustainability in post –pandemic period. *World Journal of English Language*, *15*(3), 25. https://doi.org/10.5430/wjel.v15n3p25

Ameer, A., & Ghannam, R. (2025). Education in a changing climate: a systematic review for low and middle-income countries (LMICs). *Sustainable Development*, sd.70490. https://doi.org/10.1002/sd.70490

Ammoneit, R., Turek, A., & Peter, C. (2022). Pre-service geography teachers' professional competencies in education for sustainable development. *Education Sciences*, *12*(1), 42. https://doi.org/10.3390/educsci12010042

Arantes, L., & Sousa, B. B. (2025). The sustainability consciousness questionnaire: validation among portuguese population. *Sustainability*, *17*(1), 305. https://doi.org/10.3390/su17010305

Bernert, P., Wanner, M., Fischer, N., & Barth, M. (2022). Design principles for advancing higher education sustainability learning through transformative research. *Environment, Development and Sustainability*, *27*(9), 20581–20598. https://doi.org/10.1007/s10668-022-02801-w

Birdman, J., Wiek, A., & Lang, D. J. (2022). Developing key competencies in sustainability through project-based learning in graduate sustainability programs. *International Journal of Sustainability in Higher Education*, *23*(5), 1139–1157. https://doi.org/10.1108/IJSHE-12-2020-0506

Chen, P., & Chang, Y.-C. (2024). Incorporating creative problem-solving skills to foster sustainability among graduate students in education management. *Cleaner Production Letters*, *7*, 100082. https://doi.org/10.1016/j.clpl.2024.100082

Contreras, A., Blanchard, M. A., Mouguiama-Daouda, C., & Heeren, A. (2024). When eco-anger (but not eco-anxiety nor eco-sadness) makes you change! A temporal network approach to the emotional experience of climate change. *Journal of Anxiety Disorders*, *102*, 102822. https://doi.org/10.1016/j.janxdis.2023.102822

Ding, G., He, Y., Yi, K., & Li, S. (2024). Using the divergent association task to measure divergent thinking in Chinese elementary school students. *Thinking Skills and Creativity*, *52*, 101503. https://doi.org/10.1016/j.tsc.2024.101503

Echegoyen Sanz, Y., & Martín-Ezpeleta, A. (2021). Fostering creativity in the classroom: Ecofeminist movies for a better future. *Journal of Education Culture and Society*, *12*(1), 117–130. https://doi.org/10.15503/jecs2021.1.117.130

Echegoyen-Sanz, Y., Morote, Á., & Martín-Ezpeleta, A. (2024). Transdisciplinary education for sustainability. Creativity and awareness in teacher training. *Frontiers in Education*, *8*, 1327641. https://doi.org/10.3389/feduc.2023.1327641

Eraslan, M., Kir, S., Turan, M. B., & Iqbal, M. (2024). Sustainability consciousness and environmental behaviors: examining demographic differences among sports science students. *Sustainability*, *16*(24), 10917. https://doi.org/10.3390/su162410917

Fries, J. (2025). Drama as a resource for transformative learning in sustainability education. *International Journal of Sustainability in Higher Education*, *26*(9), 412–426. https://doi.org/10.1108/IJSHE-10-2024-0756

Gericke, N., Boeve-de Pauw, J., Berglund, T., & Olsson, D. (2019). The sustainability consciousness questionnaire: The theoretical development and empirical validation of an evaluation instrument for stakeholders working with sustainable development. *Sustainable Development*, *27*(1), 35–49. https://doi.org/10.1002/sd.1859

Green, Z. A., & Rizwan, S. (2024). A creative self-efficacy course for nurturing academic thriving and academic engagement among college students in Pakistan. *Learning and Individual Differences*, *114*, 102495. https://doi.org/10.1016/j.lindif.2024.102495

Hasibuan, S., Yustina, Y., & Wahyuni, R. (2025). Bridging cognitive skills and environmental awareness: Critical and creative thinking as predictors of digital ecoliteracy. *Frontiers in Education*, *10*, 1705676. https://doi.org/10.3389/feduc.2025.1705676

Hong, Q. N., Fàbregues, S., Bartlett, G., Boardman, F., Cargo, M., Dagenais, P., Gagnon, M.-P., Griffiths, F., Nicolau, B., O'Cathain, A., Rousseau, M.-C., Vedel, I., & Pluye, P. (2018). The Mixed Methods Appraisal Tool (MMAT) version 2018 for information professionals and researchers. *Education for Information*, *34*(4), 285–291. https://doi.org/10.3233/EFI-180221

Horcea-Milcu, A.-I. (2022). Values as leverage points for sustainability transformation: Two pathways for transformation research. *Current Opinion in Environmental Sustainability*, *57*, 101205. https://doi.org/10.1016/j.cosust.2022.101205

Hu, R., & Mou, S. (2025). Outdoor education for sustainable development: a systematic literature review. *Sustainability*, *17*(8), 3338. https://doi.org/10.3390/su17083338

Işıkgöz, M. E., & Öztunç, M. (2026). From inclusion to sustainability: a systematic review of research trends in sustainable inclusive education (2015–2025). *Sustainable Development*, sd.71001. https://doi.org/10.1002/sd.71001

Karakuyu, A., & Karafil, B. (2026). Recycling-Based STEM education for sustainability: effects on secondary school students' STEAM attitudes, recycling behaviours and design thinking skills. *Sustainability*, *18*(4), 1820. https://doi.org/10.3390/su18041820

Khalid, M., Saad, S., Abdul Hamid, S. R., Ridhuan Abdullah, M., Ibrahim, H., & Shahrill, M. (2020). Enhancing creativity and problem-solving skills through creative problem solving in teaching mathematics. *Creativity Studies*, *13*(2), 270–291. https://doi.org/10.3846/cs.2020.11027

Koong Lin, H.-C., Lu, R.-S., & Wang, T.-H. (2025). Writing is coding for sustainable futures: reimagining poetic expression through human–ai dialogues in environmental storytelling and digital cultural heritage. *Sustainability*, *17*(15), 7020. https://doi.org/10.3390/su17157020

Liao, C.-W., Wang, C.-C., Wang, I.-C., Lin, E.-S., Chen, B.-S., Huang, W.-L., & Ho, W.-S. (2025). Integrating virtual reality into art education: enhancing public art and environmental literacy among technical high school students. *Applied Sciences*, *15*(6), 3094. https://doi.org/10.3390/app15063094

Martín-Ramos, P., Sánchez-Hernández, E., Fourati-Jamoussi, F., Annelin, A., Charatsari, C., Ferreira-Santos, J., Doran, P., Naves-Sousa, D., Eugenio-Gozalbo, M., Lo Giudice, L. A., Oliveira-Pinto, F., & Navas-Gracia, L. M. (2025). Operationalizing the European sustainability competence framework: Development and validation of learning outcomes for GreenComp. *Open Research Europe*, *5*, 203. https://doi.org/10.12688/openreseurope.20927.2

Molnár, G., & Pásztor, A. (2025). Reasoning skills or creativity: Which is more important in complex problem-solving? *Thinking Skills and Creativity*, *57*, 101865. https://doi.org/10.1016/j.tsc.2025.101865

Mróz, A., & Ocetkiewicz, I. (2021). Creativity for sustainability: how do polish teachers develop students' creativity competence? Analysis of research results. *Sustainability*, *13*(2), 571. https://doi.org/10.3390/su13020571

Mróz, A., & Ocetkiewicz, I. (2024). Anticipatory thinking as a key competence in management for sustainability: The results of research among polish teenagers. *Sustainability*, *16*(22), 10036. https://doi.org/10.3390/su162210036

Nepraš, K., Strejčková, T., & Kroufek, R. (2022). Climate change education in primary and lower secondary education: systematic review results. *Sustainability*, *14*(22), 14913. https://doi.org/10.3390/su142214913

Niu, W., & Cheng, L. (2022). Editorial: Creativity and innovation in STEAM education. *Frontiers in Education*, *7*, 1045407. https://doi.org/10.3389/feduc.2022.1045407

Ovais, D. (2023). Students' sustainability consciousness with the three dimensions of sustainability: Does the locus of control play a role? *Regional Sustainability*, *4*(1), 13–27. https://doi.org/10.1016/j.regsus.2023.02.002

Pacis, M., & VanWynsberghe, R. (2020). Key sustainability competencies for education for sustainability: Creating a living, learning and adaptive tool for widespread use. *International*

Journal of Sustainability in Higher Education, *21*(3), 575–592. https://doi.org/10.1108/IJSHE-12-2018-0234

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., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, n71. https://doi.org/10.1136/bmj.n71

Patonah, S., Budiati, I., & Hayat, M. S. (2025). Practicality of STEAM–SDGs-Based IPAS learning for vocational students in the green economy era. *Online Learning in Educational Research (OLER)*, *5*(2), 369–394. https://doi.org/10.58524/oler.v5i2.884

Piirto, J. (2021). Organic Creativity for 21st Century Skills. *Education Sciences*, *11*(11), 680. https://doi.org/10.3390/educsci11110680

Runco, M. A. (2025). Updating the standard definition of creativity to account for the artificial creativity of AI. *Creativity Research Journal*, *37*(1), 1–5. https://doi.org/10.1080/10400419.2023.2257977

Sadak, M., Incikabi, L., Ulusoy, F., & Pektas, M. (2022). Investigating mathematical creativity through the connection between creative abilities in problem posing and problem solving. *Thinking Skills and Creativity*, *45*, 101108. https://doi.org/10.1016/j.tsc.2022.101108

Saeed, B. A., & Ramdane, T. (2022). The effect of implementation of a creative thinking model on the development of creative thinking skills in high school students: A systematic review. *Review of Education*, *10*(3), e3379. https://doi.org/10.1002/rev3.3379

Sass, W., Pauw, J. B., Maeyer, S. D., & Petegem, P. V. (2021). Development and validation of an instrument for measuring action competence in sustainable development within early adolescents: The action competence in sustainable development questionnaire (ACiSD-Q). *Environmental Education Research*, *27*(9), 1284–1304. https://doi.org/10.1080/13504622.2021.1888887

Shaw, A. (2021). It works…but can we make it easier? A comparison of three subjective scoring indexes in the assessment of divergent thinking. *Thinking Skills and Creativity*, *40*, 100789. https://doi.org/10.1016/j.tsc.2021.100789

Sigit, D. V., Ristanto, R. H., Nurrismawati, A., Komala, R., Prastowo, P., & Katili, A. S. (2023). Ecoliteracy's contribution to creative thinking: A study of senior high school students. *Journal of Turkish Science Education*, *20*(2), 356–368. https://doi.org/10.36681/tused.2023.020

Sipahi, Y., & Bahar, A. K. (2025). Mathematical creativity: A systematic review of definitions, frameworks, and assessment practices. *Education Sciences*, *15*(10), 1348. https://doi.org/10.3390/educsci15101348

Stanley, S. K., Hogg, T. L., Leviston, Z., & Walker, I. (2021). From anger to action: Differential impacts of eco-anxiety, eco-depression, and eco-anger on climate action and wellbeing. *The Journal of Climate Change and Health*, *1*, 100003. https://doi.org/10.1016/j.joclim.2021.100003

Suherman, S., & Vidákovich, T. (2025). Creative self-efficacy, attitudes, creative style, and environmental literacy: Promoting mathematical creative thinking. *The Journal of Educational Research*, *118*(5), 475–485. https://doi.org/10.1080/00220671.2025.2495329

Thomas, J., & Harden, A. (2008). Methods for the thematic synthesis of qualitative research in systematic reviews. *BMC Medical Research Methodology*, *8*(1), 45. https://doi.org/10.1186/1471-2288-8-45

Tight, M. (2021). Twenty-first century skills: Meaning, usage and value. *European Journal of Higher Education*, *11*(2), 160–174. https://doi.org/10.1080/21568235.2020.1835517

Toma, R. B., Ortiz-Revilla, J., & Greca, I. M. (2024). Development and validation of a multiple-choice test for sustainability competence in primary school using the GreenComp framework. *International Journal of Educational Research Open*, *7*, 100388. https://doi.org/10.1016/j.ijedro.2024.100388

Vasilopoulos, F., & Dumontheil, I. (2025). Effect of a creative dance-based physical education intervention on primary school children's creativity and self-regulation: A pilot study. *Psychology of Aesthetics, Creativity, and the Arts*. https://doi.org/10.1037/aca0000732

Winarto, W., Rosada, D., Wibowo, W. S., Rahayu, D. P., Pradana, P. W., & Shidiq, G. A. (2025). The impact of STEM-EfSD games on enhancing students' creative thinking and environmental literacy. *European Journal of STEM Education*, *10*(1), 23. https://doi.org/10.20897/ejsteme/17354

Wu, Y. J., Wu, C.-H., & Peng, K.-L. (2025). Effects of creativity styles on learning engagement and motivation in STEAM education. *Sustainability*, *17*(6), 2755. https://doi.org/10.3390/su17062755

Xiong, X., & Ren, S. (2025). Combining creative problem solving with science fiction films to promote creative thinking in science education. *Science & Education*. https://doi.org/10.1007/s11191-025-00700-w