Supplementary Table S6. PRISMA 2020 checklist

Manuscript: “AI-Augmented Experiential Pedagogies for Transversal Competencies in Engineering and STEM Higher Education: A Systematic Review for Sustainable Development Education” (Sustainability, sustainability-4680343). Locations refer to section, figure and table numbers of the revised manuscript.

Table S6a. PRISMA 2020 checklist (main report)

Section and topic		Item #	Checklist item	Location where item is reported
TITLE	Title	1	Identify the report as a systematic review.	Title (page 1)
ABSTRACT	Abstract	2	See the PRISMA 2020 for Abstracts checklist.	Abstract; see Table S6b below
INTRODUCTION	Rationale	3	Describe the rationale for the review in the context of existing knowledge.	Sections 1.1–1.4
	Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	Section 1.4 (aim and RQ1–RQ5)
METHODS	Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	Section 2.3 (criteria C1–C4, codes E1–E5 and FT1–FT5); Section 2.8 (grouping for syntheses: core, competency-only, pedagogy-only and contextual studies); Document S1
	Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	Section 2.2 (Web of Science Core Collection, editions listed, searched 7 October 2026; Scopus and IEEE Xplore, searched 31 October 2026; no registers, websites or citation searching); Table 3; Table S1
	Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Section 2.2; Table 2 (WoS strings, limits and refinements); Table 3 (fields searched in each database); Document S1 (Scopus and IEEE Xplore strings; field-harmonisation filter and its validation on the WoS corpus and on 300 independently screened removed records); File S8 (executable filter)
	Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	Sections 2.4–2.5 (one human reviewer and an AI model per record, independent; full-text exclusions by two authors independently; arbitration by a third author); Table 4 (agreement for every AI-assisted step); Section 2.10 (AI tool)
	Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	Section 2.6 (AI first pass, verification of every value by one author, 20% independent double check; investigators not contacted); Table 4; Section 2.10; Document S3 (protocols); Table S2, sheets S2f, S2f2 and S2k (corrections)
	Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	Section 2.6 and Table 5 (one record per competency × type of measure × type of contrast; all measures and time points sought; immediate post-test as main record, delayed follow-up recorded separately; AI availability at assessment)
		10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	Section 2.6 (study, participant, intervention and AI variables; only reported information recorded); Section 2.8
	Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	Section 2.7 (MMAT 2018; “no” only for demonstrated weaknesses, “can’t tell” for missing information; mixed-methods components appraised separately; calibration by two authors; every rating verified by one author with a 20% independent double check)
	Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	Section 2.8 and Table 5 (direction of effect: positive, mixed, non-significant, negative, not determinable; non-significant not

				interpreted as no effect); Table 7 (effect sizes and confidence intervals as reported; not pooled)
	Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	Section 2.8 (core and competency-only primary studies for the outcome synthesis; pedagogy-only and contextual literature descriptive only; comparative subset defined)
		13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	Section 2.8 (directions as reported; no conversions or imputations)
		13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	Section 2.8; Tables 6, 7, 8 and A1; Figures 1–11
		13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	Sections 2.1 and 2.8 (descriptive mapping; direction-of-effect synthesis following SWiM, stratified by type of contrast and measure; no meta-analysis because of heterogeneous designs and metrics)
		13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	Section 2.8 (by competency, type of contrast and measure, AI availability at assessment, AI-use structure and number of MMAT criteria met)
		13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	Section 2.8 and Section 3.6 (robustness across databases and retrieval efforts; quality-stratified comparison)
	Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	Section 2.8 (not formally assessed; suspected publication bias considered in the certainty ratings, Table 8)
	Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	Section 2.8 (GRADE for narrative synthesis without a single effect estimate: risk of bias, inconsistency, indirectness, imprecision, publication bias)
RESULTS	Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	Sections 2.4–2.5; Figure 1 (PRISMA 2020 flow diagram); File S7
		16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	Section 2.5 (examples cited with reasons, including a retracted report); Table S2, sheets S2b–S2b5 (all excluded reports with codes and rationales)
	Study characteristics	17	Cite each included study and present its characteristics.	Section 3.1; Table 6; Figures 2–3; Appendix A, Table A1 (all included studies cited); Table S2, sheet S2h
	Risk of bias in studies	18	Present assessments of risk of bias for each included study.	Section 3.4; Figure 8; Table S2, sheet S2j (MMAT ratings for each appraised study, with the basis of each “no”)
	Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	Table 7 (comparative records with statistics, effect sizes and confidence intervals as reported); Table A1; Table S2, sheet S2i (all outcome records)
	Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	Sections 3.3 and 3.4; Tables 7 and 8
		20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	Section 3.3; Figure 7; Table 7 (direction-of-effect counts; no meta-analysis)
		20c	Present results of all investigations of possible causes of heterogeneity among study results.	Section 3.3 (by type of contrast, measure and AI availability at assessment); Section 3.4 (by MMAT criteria met; Figure 8b); Section 4.2 (by AI-use structure)
		20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	Section 3.6; Figure 11; Table S4, sheet S4a2 (description of non-retrieved reports)
	Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	Not formally assessed (Section 2.8); considered in the certainty ratings (Table 8) and discussed in Section 4.7

	Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	Section 3.4 and Table 8 (GRADE certainty for each main finding); Sections 4.1 and 4.7
DISCUSSION	Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	Sections 4.1–4.4
		23b	Discuss any limitations of the evidence included in the review.	Sections 3.4, 3.6, 4.1 and 4.7
		23c	Discuss any limitations of the review processes used.	Section 4.7
		23d	Discuss implications of the results for practice, policy, and future research.	Sections 4.4–4.6 and 5
OTHER INFORMATION	Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	Section 2.1 (not registered); Abstract
		24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	Section 2.1 (no separate protocol published; criteria, codes and forms in Supplementary Materials S1–S3)
		24c	Describe and explain any amendments to information provided at registration or in the protocol.	Section 2.1 (four amendments described); Document S1
	Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	Funding statement (back matter); role of funder stated
	Competing interests	26	Declare any competing interests of review authors.	Conflicts of Interest statement (back matter)
	Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	Data Availability Statement; Supplementary Materials S1–S8 (forms and protocols: S1, S3; extracted, coded and analysed data: S2, S4, S5; executable filter and analysis code with input and output files: S8)

Table S6b. PRISMA 2020 for Abstracts checklist

Section and topic		Item #	Checklist item	Location where item is reported
TITLE	Title	1	Identify the report as a systematic review.	Title; Abstract
BACKGROUND	Objectives	2	Provide an explicit statement of the main objective(s) or question(s) the review addresses.	Abstract (sentence 2)
METHODS	Eligibility criteria	3	Specify the inclusion and exclusion criteria for the review.	Abstract (sentence 3)
	Information sources	4	Specify the information sources (e.g. databases, registers) used to identify studies and the date when each was last searched.	Abstract (Web of Science Core Collection, Scopus and IEEE Xplore, last searched 31 October 2026)
	Risk of bias	5	Specify the methods used to assess risk of bias in the included studies.	Abstract (MMAT 2018)
	Synthesis of results	6	Specify the methods used to present and synthesise results.	Abstract (synthesis by direction of effect, separating between-group, within-group and descriptive evidence)
RESULTS	Included studies	7	Give the total number of included studies and participants and summarise relevant characteristics of studies.	Abstract (323 studies, 153 core primary studies; characteristics)
	Synthesis of results	8	Present results for main outcomes, preferably indicating the number of included studies and participants for each. If meta-analysis was done, report the summary estimate and confidence/credible interval. If comparing groups, indicate the direction of the effect (i.e. which group is favoured).	Abstract (direction of comparative outcomes by MMAT criteria met; certainty; structured vs. unconstrained AI use)
DISCUSSION	Limitations of evidence	9	Provide a brief summary of the limitations of the evidence included in the review (e.g. study risk of bias, inconsistency and imprecision).	Abstract (non-randomised comparisons, assessment with AI available, MMAT results, certainty low to very low)
	Interpretation	10	Provide a general interpretation of the results and important implications.	Abstract (last sentences)
OTHER	Funding	11	Specify the primary source of funding for the review.	Abstract (Lucian Blaga University of Sibiu)
	Registration	12	Provide the register name and registration number.	Abstract (not registered)

Source: Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi:10.1136/bmj.n71. The PRISMA checklist is licensed under CC BY 4.0 (https://creativecommons.org/licenses/by/4.0/).