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Table of contents

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List of figures

List of tables

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List of acronyms

Acronym	Description
ADDIE	Analyse, Design, Develop, Implement, Evaluate
AI	Artificial Intelligence
AIED	Artificial Intelligence in Education
AI4T	Artificial Intelligence for and by Teachers
AILit	Artificial Intelligence Literacy
CP	Creative Pedagogy
EC	European Commission
EU	European Union
5c21	Five Key Competencies for the 21st Century Education: 1 (computational thinking, critical thinking, creativity, collaboration and problem solving).
HE	Higher Education
ICT	Information and Communications Technology
ITS	Intelligent Tutoring System
MHP	Mental Health Professionals
ML	Machine-Learning
NGO	Non Governmental Organisation
OECD	Organisation for Economic Co-Operation and Development
OPD	Ongoing Professional Development
PF	Pedagogical Framework
PeDeMet	augMENTOR Pedagogical Design Model with Emerging Technologies
R&D	Research & Development
SDG	UNESCO's Sustainable Development Goals
STEM	Science, Technology, Engineering and Mathematics
SWOT	Strengths, Weaknesses, Opportunities, and Threats
TESA	Teacher Expected Student Achievement
TPACK	Technological Pedagogical Content Knowledge
UbD	Understanding by Design
WEF	World Economic Forum

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Executive Summary

The Horizon augMENTOR project aims to foster the development of essential 21st-century competencies—most notably Creativity, Critical thinking, Collaboration, and Communication (4Cs) as well as design thinking within AI-enhanced educational settings. These transversal competencies, recognised by frameworks such as those from the Organisation for Economic Co-Operation and Development (OECD), are vital for personal, academic, and professional success in a world increasingly shaped by artificial intelligence and emerging technologies.

This deliverable, D4.2, serves three key purposes in support of this vision. First, it consolidates the state-of-the-art in fostering creativity, critical thinking, collaboration and communication (following the work done in T4.1), emphasizing their integration into AI-based educational scenarios such the ones developed by the augMENTOR pilots. Second, it proposes a comprehensive pedagogical framework grounded in creative pedagogy (following the work done in T4.2), which merges creative teaching, teaching for creativity, and creative learning. This framework has been used to ensure that the development of the 4Cs competencies is embedded in the augMENTOR solution.

Third, building on insights from prior tasks and the assessment methodologies developed in T4.3, this report presents a set of actionable educational and technological recommendations (produced in T4.4) for leveraging emerging technologies to enhance creativity and design thinking. These recommendations reflect not only theoretical underpinnings but also practical considerations based on user experience and pedagogical effectiveness.

Finally, this deliverable presents key findings on the integration of Creative Pedagogy (CP) and AI-supported systems across the augMENTOR project. It confirms that aligning the three dimensions of creative pedagogies (creative teaching, teaching for creativity, and creative learning) with AI design supports the development of the 4Cs. Results from pilot implementations show that co-designed, context-specific scenarios and AI-enabled scaffolding improve learner engagement, reflection, and transversal competence development. These insights inform the pedagogical and technological recommendations proposed in Section 6.

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1 Introduction

1.1 Objective and structure of the deliverable

D4.2 constitutes the third and final deliverable for WP4, which was led by the Université Côte d'Azur. Its primary objective is to describe the use of creative pedagogy within the augMENTOR solution and to evaluate the overall pedagogical approach in effectively fostering the 4Cs among learners. D4.2 also seeks to evaluate augMENTOR's ability to support creativity and innovation through three interrelated elements: creative teaching, teaching for creativity, and creative learning. These evaluations are made through the lens of prior deliverables, D4.1 and D4.3, as well as in conjunction with partner work groups - specifically our work with WP3 as reflected in Figure 1.

Deliverable D4.2 begins by reviewing the underlying theoretical framework of the augMENTOR solution, focusing on CP and its relevance to EU policy, education innovation, and the integration of AI in educational settings. These ideas are then explored further as we detail how CP informs instructional design within the augMENTOR solution, providing examples of how AI tools can support creative teaching, teaching for creativity, and creative learning. Next, we evaluate the results of the pilots and augMENTOR's effectiveness in supporting the development of the 4Cs. Finally, we provide our recommendations to developers, educators, and policymakers on potential iterations and integrations of the augMENTOR solution in their practices.

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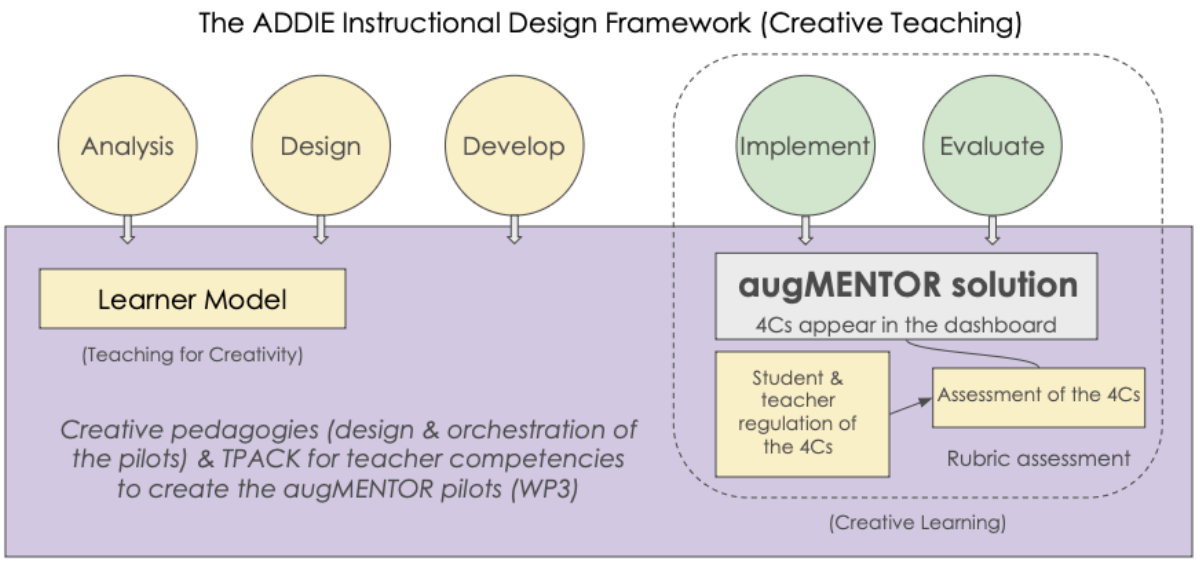

Figure 1. *From the learning design analysis to the assessment process*

1.2 Integration of the deliverable within the WP3 pedagogical framework

D4.2 extends the pedagogical vision set out in D3.1 by embedding creative pedagogy at the core of its scenario-based learning design. Drawing on the TESA framework, this deliverable illustrates how technology-augmented educational scenarios can support imaginative, learner-centred, and participatory learning processes. Rather than focusing solely on content delivery, D4.2 emphasises the co-construction of knowledge through open-ended activities, collaborative problem-solving, and reflective engagement. Within each unit, teaching strategies and learning materials are purposefully designed to promote creativity, not only as an outcome but as an active process of exploration, experimentation, and transformation. In this way, D4.2 demonstrates how the integration of AI technologies can enhance, rather than constrain, the pedagogical possibilities of creative teaching and learning. Ultimately, this alignment between pedagogical intent and adaptive system behaviour ensures that the augMENTOR solution remains both educationally robust and technologically responsive across diverse learning contexts.

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2 Theoretical Framework

2.1 Creative pedagogies, the 4Cs and AI

The proposed AILit Framework for primary and secondary education (OECD, 2025) integrates the 4Cs as key elements for developing the four domains of AI literacy. It also includes *computational thinking*, as presented in the #5c21 framework as a key component for AI literacy (Romero, 2024) and self and social awareness.

The AILit Framework is a joint initiative of the European Commission (EC) and the OECD, which aims to contribute to the innovative domain of the PISA 2029 assessment and supports the EU's goals to promote quality and inclusive digital education and skills.

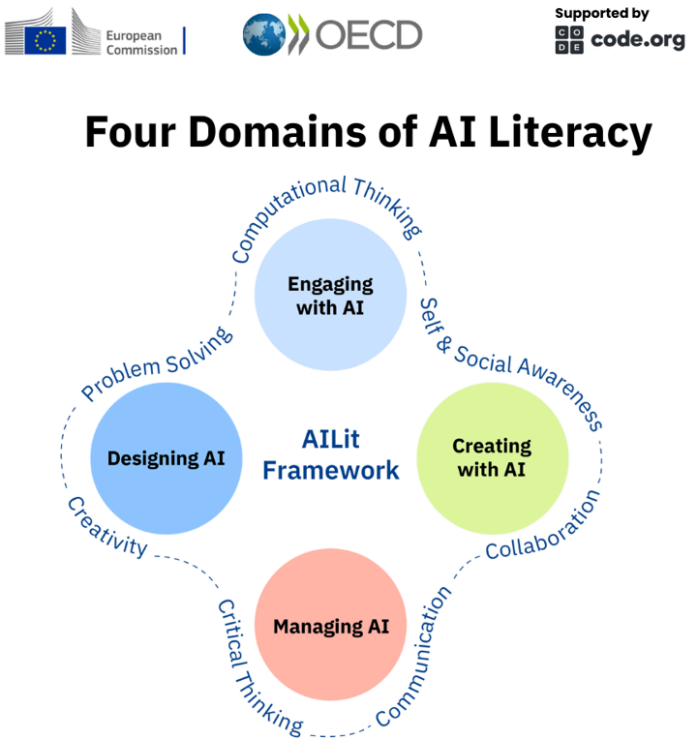

Figure 2. *Four Domains of AI Literacy (OECD, 2025), including the 4Cs and #5c21*

Creative pedagogies are increasingly recognised as essential for developing the 4Cs and #5c21 competencies learners require in the age of AI. As outlined by Cremin and Chappell (2021), creative pedagogy involves not only fostering learner creativity, but also enabling teachers to teach creatively, using imaginative and responsive approaches. This model is particularly relevant in the context of AI integration in education, where human creativity can be enhanced through the use of AI systems.

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2.2 Interrelation of the components of creative pedagogies

The three interrelated components of creative pedagogies (creative teaching, teaching for creativity, and creative learning) enable students and educators to engage meaningfully with AI-enhanced tools and environments.

2.2.1 Creative teaching

Creative teaching refers to the educator's ability to design and deliver content in imaginative, responsive, and flexible ways that engage learners. In AI-supported classrooms, this may include the use of adaptive technologies, interactive simulations, or generative content tools to personalise instruction, scaffold learning, and stimulate curiosity. For instance, AI-enhanced platforms such as *NoRILLA* adapt to students' inquiry patterns, enabling teachers to facilitate hands-on STEM exploration while maintaining pedagogical control (Yannier, 2024). Similarly, the AI4T project has demonstrated how teachers can co-design learner-centred activities using AI-assisted tools, fostering professional creativity and promoting digital innovation in teaching practices.

2.2.2 Teaching for creativity

Teaching for creativity focuses on fostering students' capacity to generate novel ideas, solve problems in original ways, and engage in divergent thinking. Lucas et al. (2023) emphasise the importance of teaching strategies that encourage students to develop new solutions. In AI-supported learning, this may involve students designing AI-driven narratives, interacting with algorithmic systems, or participating in collaborative problem-solving scenarios. The Generation AI project[1], for example, encourages students to create original stories and media projects using AI tools, thus integrating technical skill development with creative expression. This aligns with Beghetto and Zamana's (2025) work on the importance of enhancing human creativity through the use of AI.

2.2.3 Creative learning

Creative learning centers on the learner's experience as an active, autonomous, and imaginative process. It occurs when students engage in open-ended tasks that allow

[1] Generation AI is a Erasmus+ programme of the European Union that supports educators and young learners to understand the fundamentals of AI. More information is available here.

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for personal expression, collaboration, and reflection. In AI-integrated contexts, creative learning is supported by environments that promote inquiry, experimentation, and metacognitive awareness. These experiences align with Vygotsky's (1978) theory of learning as socially mediated and contextually situated and demonstrate how AI can serve as both a tool and a partner in meaning-making processes.

The synergy between creative teaching, teaching for creativity, and creative learning is particularly relevant in the context of the AILit Framework, which positions the 4Cs alongside computational thinking and socio-emotional skills as foundational for AI literacy (OECD, 2025). These three pedagogical dimensions are not isolated strategies, but interdependent processes that collectively transform how knowledge is constructed, shared, and applied. When effectively combined, they support the development of learner and teacher agency (Frøsig & Romero, 2024), creative intention and regulation (Leroy & Romero, 2022), and ethical awareness in learners, fostering a culture of innovation and responsiveness in educational settings.

2.3 Relevancy and alignment of creative pedagogies within EU policy, UNESCO and OECD policies

Creative pedagogies have gained significant relevance and alignment within contemporary education policy frameworks at both European and global levels. The European Union (EU) emphasises creativity as a key competence for lifelong learning, highlighting its role in fostering innovation, adaptability, and active citizenship in the European Key Competences for Lifelong Learning Framework (Europaea, 2018). The DigComp (EC, 2022) and the updated DigComp 2.2 incorporate the creative approach in the development of digital competencies and also specifically integrate the need to develop AI literacy (Van Audenhove et al., 2024; Vuorikari & Holmes, 2022).

UNESCO advocates for creative and transformative pedagogies as essential to achieving Education for Sustainable Development (ESD) and the goals outlined in SDG 4, particularly in promoting inclusive, equitable, and quality education. OECD policy directions, particularly through the OECD Future of Education and Skills 2030, recognise creativity, critical thinking, and collaboration as core competencies necessary for navigating complex global challenges. Across these frameworks, creativity is not framed merely as an individual talent but as a social, developmental, and contextual

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capacity integral to educational innovation. The integration of creative pedagogies aligns with these broader policy goals to reimagine education systems that are more participatory, learner-centred, and responsive to the demands of digital transformation and democratic participation.

2.4 Artificial Intelligence and creative pedagogies

Available AI has shown the potential to transform the learning experience in significant ways. Since its public release in 2022, it is already being employed in a number of educational use cases by learners, educators, and policymakers alike. Yet, for all of its potential, AI is not, in and of itself, an educational framework or teaching strategy. This rationale directly informs the instructional design methodology outlined in Section 5.1, where AI and CP are operationalised using the ADDIE model. While AI is undoubtedly a powerful tool, it cannot function as a substitute for evidence-based pedagogical frameworks. Here is where creative pedagogy can play a mediating role when coupled with AI, lifting it from its status as a mere tool to a collaborative partner or even a transformative agent. Acting as both an enabler and a safeguard, CP provides the necessary pedagogical scaffolding to integrate AI into learning frameworks, while also acting as a counterbalance to potential issues of misuse, over-dependence, and deskilling (Krakowski, 2025). A helpful analogy might be to view AI as a vehicle with CP providing the driver's knowledge, maps, and safety rails to ensure that the ride is not only efficient, but safe and intentional.

More directly, CP works in tandem with the AI-powered toolkit to accomplish augMENTOR's goal of offering personalised, human-centred learning through individual learner profiles and data-driven recommendations. The AI toolkit provides real-time, digestible feedback, while CP grounds those recommendations in an ethically sound, learner-centred framework that seeks to develop disciplinary knowledge as well as transversal competencies like the 4Cs. Together, they enable the co-construction of dynamic educational pathways that prioritise human agency and power for more impactful learning experiences.

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3 Creative pedagogy supported by AI-supported systems

3.1 Review of current initiatives

Here, we describe five initiatives to provide context around the current use of CP to regulate and scaffold AI use in educational settings. We include them here as an example of similar projects that are evaluating and integrating CP to leverage the strengths of AI in the development of the 4Cs and #5c21 transversal skills. Two of the initiatives focus on Ongoing Professional Development (OPD) for teachers, two on supporting teacher practice within the classroom, and one on children exploring Science, Technology, Engineering, and Mathematics (STEM) concepts through a mixed-reality system.

European projects aiming to support teachers to support creative pedagogies through the use of AI :

- The Erasmus+ AI Pioneers (https://aipioneers.org/) project promotes innovative, ethical, and creative uses of AI in adult and vocational education. The project aims to empower educators to become "AI Pioneers" by co-developing pedagogical toolkits and classroom strategies rooted in creative, real-world scenarios. The initiative emphasises co-design, critical thinking, and cross-sector experimentation, enabling learners to actively shape AI-enhanced learning environments.
- Among the initiatives focusing on teacher training, the AI4T (Artificial Intelligence for and by Teachers, https://www.ai4t.eu/) initiative, funded through Erasmus+, aims to empower educators to co-design creative, learner-centred activities using AI-assisted tools.

AI projects supporting K12 teachers to design creative activities with AI:

- The Erasmus+ AI-Teach (https://www.aiteachproject.eu/) aims to support primary school teachers in adopting AI through creative pedagogies. It promotes playful, exploratory learning by introducing AI through hands-on, story-based tasks. The initiative enables teachers to reflect critically and co-create ethical, child-friendly learning activities that embed AI in an inclusive, creative classroom environment.
- The Erasmus+ project Generation AI (https://generation-ai.eu/) aims to foster creativity and computational thinking among young learners. It equips teachers with engaging toolkits to introduce AI through problem-solving, storytelling, and

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creative media production. By embedding AI in cross-curricular projects, Generation AI helps children explore technology through imagination and play.

Projects supporting creative activities:

- NoRILLA (Novel Research-based Intelligent Lifelong Learning Apparatus, https://www.norilla.com/), a mixed-reality AI learning platform that combines physical and virtual interaction to support inquiry-based STEM education. By adapting to students' experimentation patterns, NoRILLA fosters hands-on, creative exploration. It has been successfully deployed in classrooms and museums, helping learners engage in authentic, constructive activities.

3.2 Analysis of current initiatives for informing the integration of creative pedagogy in the augMENTOR solution

To ground our decisions regarding the creative pedagogical approach applied within the augMENTOR solution, we conducted a SWOT analysis on five key peer-reviewed research papers. This analysis helped to identify the strengths, weaknesses, opportunities, and threats associated with integrating AI into creative pedagogical frameworks. While two systematic literature reviews were previously conducted by both WP2 (see deliverable D2.1) and WP3 (see deliverable D3.1), given the speed at which AI is evolving, as well as the introduction of new use cases, we thought it prudent to revisit the existing body of research to ensure relevance and completeness. Furthermore, this SWOT analysis was focused specifically on the recent developments associated with CP and the 4Cs. A brief description of the included studies is integrated in Annex B. The analysis leads to the following *SWOT Matrix of AI and Creative Pedagogies* presented in Table 1.

Table 1. *SWOT Matrix of AI and Creative Pedagogies*

	Helpful	**Harmful**
Internal Origin	**Strengths** • Personalized support enhances learning outcomes (Möller et al., 2024) • Boosts creativity, confidence, and skill transfer (Habib et al., 2025) • AI + PBL improves ethical reasoning and problem-solving (Kong et al., 2024)	**Weaknesses** •How teacher AI literacy limits adoption (Wu et al., 2024) Deskilling risk without pedagogical alignment (Habib et al., 2025)

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	• AI-assisted collaborative learning boosts teacher literacy (Wu et al., 2024)	• Algorithmic bias, data privacy issues (Habib et al., 2025; Wu et al., 2024) • Misalignment if pedagogy is not adapted to learner levels (Kong et al., 2024)
External Origin	**Opportunities** • Enables interdisciplinary and future-oriented skill development (Kong et al., 2024) • Scalable AI tutoring for HE and vocational education (Möller et al., 2024) • Game-based and situated AI learning design (Wu et al., 2024) • Promotes human agency and ethical engagement with GenAI (Habib et al., 2025)	**Threats** • AI may increase teacher dependency (Kasepalu et al., 2022) • Long-term cognitive risk from over-reliance (Möller et al., 2024) • Lack of ethical AI training reduces critical engagement (Wu et al., 2024) • Risk of AI dominating creative output (Habib et al., 2025)

AI-integrated creative pedagogies offer significant strengths, notably enhanced personalised support and learning efficiency (Möller et al., 2024), improved problem-solving and ethical reasoning through project-based learning (Kong et al., 2024), and increased creative confidence and skill application in higher education (Habib et al., 2025). However, limitations persist, such as low teacher AI literacy, ethical concerns around algorithmic bias, and the need for adaptation across learner contexts (Wu et al., 2024; Kasepalu et al., 2022). Opportunities lie in fostering interdisciplinary skills and scalable learning models (Möller et al., 2024; Kong et al., 2024), while threats include teacher dependency, deskilling, and reduced critical engagement if AI is used without pedagogical grounding (Habib et al., 2025; Wu et al., 2024).

The insights from this SWOT analysis directly inform the instructional design decisions presented in Section 5.1 and the concrete implementation models described in Section 5.2, ensuring that the design is both theoretically grounded and empirically tested.

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4 Integration of creative pedagogy in the augMENTOR solution

One of the main tasks of education in the 21st century is the development of creative thinking. The forecasts for 2025 by analysts at the World Economic Forum (WEF, 2020) rank creativity among the most important skills. This is echoed by the Future of Jobs Report 2023 (WEF, 2023), which lists creative thinking as the most sought-after skill in their forecast until 2027. People with creative thinking skills are better able to develop innovative solutions and navigate today's rapidly evolving society (Pellegrino and Hilton, 2012). Vincent-Lancrin et al. (2019) highlight how creative thinking contributes to the cognitive, social, emotional, and socio-economic development of individuals and democratic societies more broadly. This highlights the importance of teaching creativity, which is demonstrated by its application in various fields. Contrary to popular belief, creativity is not an innate or inborn talent. Rather, creativity can be enhanced through specific training and pedagogical support (Lubart and Thornhill-Miller, 2019).

The need to effectively teach creative thinking skills across disciplines has become increasingly salient with the commercial introduction and pervasive use of AI and generative AI (GenAI), which have already begun to influence humans' creative processes (Vinchon et al., 2023).

Some researchers believe that the use of AI in creative activities is ambiguous and requires further study. In particular, Habib et al. (2025) note that AI tools can enhance ideation, but overreliance can diminish students' confidence. Eapen and Finkenstadt (2024) report that students may feel discouraged when AI-generated outputs are perceived as more polished or efficient than their own work.

4.1 Methodological approach

The augMENTOR pedagogical methodology is grounded in the ADDIE instructional design framework, which supports structured, iterative development of creative learning experiences. Each phase of Analysis, Design, Development, Implementation, and Evaluation (ADDIE) is infused with the principles of Creative Pedagogy and calibrated through the learner modelling PeDeMET framework from WP3. PeDeMET was developed as a dynamic system for profiling learners and personalising learning experiences by considering their creative thinking, problem-solving approaches, motivational states, and interaction patterns. During the Analysis phase, educators, developers, and learners collaborate to identify contextual challenges and target

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transversal competencies, reinforcing Hayes' (2003) view that stakeholder participation enhances educational impact. The Design and Development phases draw from the Understanding by Design (UbD) framework (Wiggins & McTighe, 2012), emphasising backward planning to align AI-based scaffolding and CP strategies with clearly defined learning goals. Implementation focuses on learner agency, using AI tools to facilitate co-constructed criteria and formative assessment practices, thereby operationalising creative teaching and learning. Finally, the Evaluation phase considers context-sensitive assessments of the 4Cs based on the adaptations of the rubrics for each pilot (See Annex A).

Figure 3 shows how elements of UbD can integrate CP into the design and development of AI scaffolded lessons that support the development of the 4Cs. During the planning phase, educators leverage AI-based recommendations and backwards planning to determine learning goals and decide on the appropriate creative teaching strategies. These strategies are operationalised during the implementation phase where educators and learners benefit from personalised AI feedback to co-construct individual success metrics. Finally, the evaluation phase utilises contextually designed rubrics and AI-generated analytics to both evaluate the development of the 4Cs competencies and provide personalised learning recommendations.

This approach ensures that creative pedagogy is not only embedded in augMENTOR's instructional design, but also systematically evaluated through ethical and learner-centred AI integration.

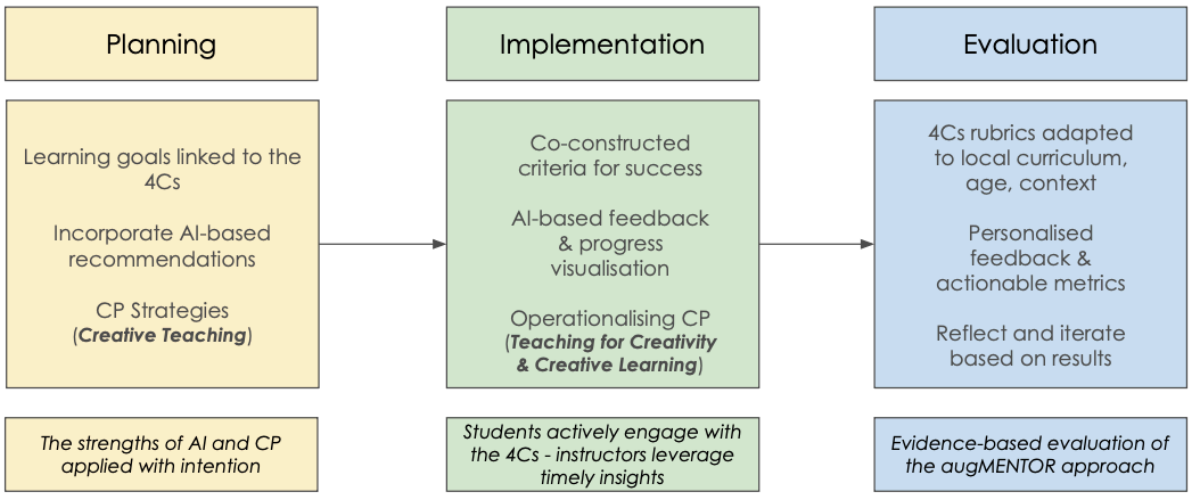

Figure 3. *How the three phases of UbD, planning, implementation, and evaluation, are integrated in the augMENTOR pedagogical framework*

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In order to support the pilots's integration of the 4Cs in the augMENTOR pedagogical methodology, a variety of support materials were offered, including quarterly meetings, professional development resources, and workshops. The initial workshops, conducted in 2023 and 2024, focused on developing the pilot partners' understanding of transversal competencies with an emphasis on the 4Cs: creativity, collaboration, critical thinking, and communication. Later workshops focused on providing the pilots practical strategies for integrating the 4Cs into their courses. Pilot partners were also invited to attend the monthly WP4 meetings as well as other meetings set up for the express purpose of addressing issues and answering outstanding questions. To complement these efforts, and in response to any gaps identified during the events, instructional materials were created, such as the 4Cs one-sheets described in D4.3 and now available for download on the augMENTOR website. Among the first workshops (2023 and 2024), we worked together on the understanding of the transversal competencies, focusing on the 4Cs. In a second stage, we developed meetings with each of the pilot agents in order to personalise the creative pedagogy strategies but also the assessment of the 4Cs through the instantiation of each component of the 4Cs according to the pilot course learning objectives and context.

4.1.1 How CP informs instructional design within the augMENTOR solution

The Analysis, Design, Development, Implementation, and Evaluation (ADDIE) provides an iterative framework that aligns well with the goals of learning design for the augMENTOR solution. Figure 4 introduces the ADDIE five phases.

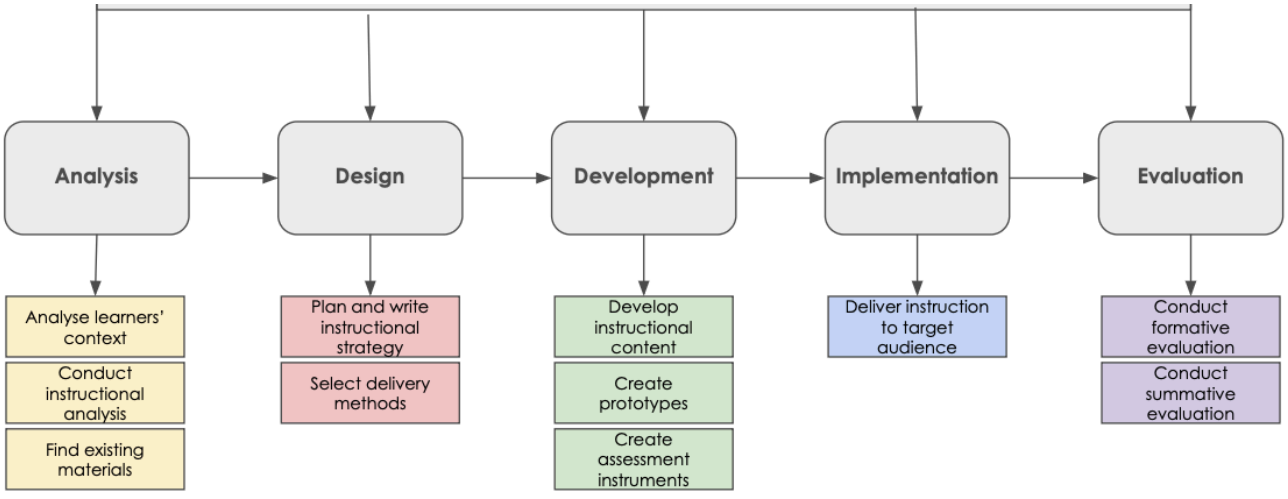

Figure 4. *The ADDIE model for instructional design*

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At the Analysis stage, educators and technologists collaboratively identify learners' needs, context-specific challenges, and desired transversal competencies. Echoing Hayes' (2003) assertion that "co-construction clearly recognizes that improvements in education are much more successful if stakeholders are actively involved" (p. 230), this phase includes learners, educators, and developers as co-designers of meaningful learning experiences.

The Design and Development phases are guided by principles from Understanding by Design (Wiggins & McTighe, 2012), which advocate for backward planning or beginning with the end in mind. Instead of focusing solely on content delivery, augMENTOR frames instruction around what learners should "know, value, understand, and do" (Hayes, 2003, p. 232). Learning activities, AI-based scaffolding, and creative pedagogical strategies are aligned with these goals, enabling personalised pathways that are both measurable and meaningful.

During implementation, educators facilitate learning through a creative pedagogy lens, engaging learners in co-creating success criteria and formative assessments. Hayes (2003) emphasises that when students receive performance tasks and expectations upfront, they can clarify their goals, receive timely feedback, and iterate on their work—practices supported by the augMENTOR platform through AI-enhanced learning environments. In the Evaluation phase, the platform applies methods from Task 4.3 to assess learning outcomes, combining tools to ensure rich, reflective, and context-aware evaluation of 21st-century competencies. This design is validated through pilot implementations detailed in Section 5.2 and supported by formative tools shown in Annex A.

4.2 Integration in the four pilots

This section provides a brief description outlining how the augMENTOR solution was supporting each of the four pilot partners in their courses. For each pilot, the creative pedagogy principles and the evaluation of the 4Cs has been integrated as a way to facilitate the data harvest for the augMENTOR solution. Each of the following descriptions was provided to WP4 by the pilots and we gratefully acknowledge their ongoing cooperation and collaboration in the completion of this deliverable.

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4.2.1 Innovative Training Programmes for Pre-service Teachers - UPATRAS

The "ICT in Education" course at the University of Patras has been piloted over two academic years (2023/2024 and 2024/2025) using the augMENTOR pedagogical framework, which applies the PeDeMET framework for design purposes and TESA for classroom implementation. The course enables future teachers to effectively incorporate ICT tools into their teaching practice and progressively improve the development of three important skills: creativity, critical thinking, and collaboration.

During the initial year, the emphasis lay in the use of scenario design to promote creativity and critical thinking. Generally, the majority of the students experienced consistent progress over the course of the semester, attaining high grades in both competencies. Tutors noted increasing confidence in generating novel ideas and assessing the pedagogic suitability of the integrated digital tools. Self-study reflections, recorded through face-to-face workshops, indicated more significant engagement and meaningful use of the technology—insights gathered through the framework of Activity Theory.

In the current year, collaboration was incorporated as the core focus. While classes are ongoing, preliminary outcomes reflect improvements in all areas across the three competencies. Preliminary evidence is positive, with more balanced and productive team collaboration and more embedded creative and critical components within team projects. While the pilot is ongoing, the direction is positive and aligned with the first year's findings.

4.2.2 Emerging technologies in Adult Education and Life-Long Learning settings - IASIS

Between April 2024 and June 2025, IASIS pilot entered a crucial phase of hands-on implementation, with a strong focus on developing the 4Cs—Communication, Collaboration, Critical Thinking, and Creativity—among Mental Health Professionals (MHPs). This phase followed an intensive preparation period, during which the IASIS course was shaped and refined through more than 90 online and in-person workshops. In total, more than 283 trainers and learners took part, completing the course's four main training areas. These same groups were then given access to the augMENTOR platform, where they provided valuable feedback and helped fine-tune its usability and relevance.

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Throughout the pilot, participants showed clear growth in communication—connecting effectively with a wide range of service users, overcoming language and emotional barriers, and using both verbal and non-verbal tools to support those they work with. The inclusion of multimedia content within Moodle made the learning process more engaging, accessible, and intuitive for everyone involved.

Collaboration also flourished. Learners worked well together, clearly understood their objectives, and demonstrated strong organizational and decision-making skills within their teams. Critical thinking came to life through hands-on tasks and exercises that mirrored real-world scenarios from the mental health field, allowing participants to look at challenges from different perspectives and apply thoughtful reasoning.

Creativity was not just encouraged—it was embedded throughout the course design. Participants were given the freedom to try new approaches, tailor learning strategies to their own professional settings, and experiment with different tools. This flexibility allowed them to connect deeply with the material and bring fresh thinking to complex situations. Overall, this pilot phase was a milestone, highlighting how adaptive, AI-supported training can truly enrich mental health education.

A big part of what made this possible was the intentional use of creative pedagogy. The IASIS course took a learner-centred, inquiry-based approach, where active engagement, exploration, and reflection were integrated into each activity. Learners engaged in digital storytelling, role-playing, brainstorming activities, and group-based problem-solving—all grounded in real-life mental health challenges. This dynamic and inclusive environment helped trainers and learners feel safe to take risks, reflect, iterate, and learn from both their successes and failures, while also giving them the chance to adapt these tools into their real-world life conditions. It also supported multimodal expression, encouraging learners to submit assignments in formats that worked best for them—videos, audio, visual materials, infographics and more—bringing in diverse cultural and global perspectives.

In parallel, the IASIS pilot took meaningful steps toward promoting green skills by shifting to fully digital delivery. By running all training activities through platforms like Moodle and the augMENTOR solution, there was limited need for paper materials or physical resources. For professionals working in mental health and humanitarian aid—fields where paper-based documentation is still very common—this transition posed a real challenge. Yet, the augMENTOR platform made the shift manageable, offering a secure, efficient, user-friendly, and intuitive digital workspace that helped participants adapt to sustainable, paperless workflows. This method not only reduced the

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environmental impact of the training but also facilitated the development of essential digital skills for eco-conscious, professional environments.

4.2.3 Leapfrogging Industry 4.0 technologies for Civic Society watchdogs and EU Civilian Missions - KTU

The pilot "Leapfrogging Industry 4.0 Technologies for Civic Society Watchdogs and EU Civilian Missions", led by KTU, aims to empower civil society actors and EU civilian mission personnel with cutting-edge ICT skills using the augMENTOR pedagogical framework. The pilot course was delivered via TryHackMe and Moodle platforms, allowing for a comparative evaluation of learner engagement and development. TryHackMe demonstrated a slower, more gradual drop-out rate, suggesting higher sustained engagement, likely due to its task-orientated, bite-sized learning approach. In contrast, Moodle exhibited faster early drop-off but supported more complex and in-depth content, encouraging deeper learning over longer sessions. The development of the 4Cs, Creativity, Critical Thinking, Collaboration, and Communication, is a central focus of the overall project. Initially, only creativity and critical thinking were assessed in the pilot due to TryHackMe's constraints. However, with the course's recent migration to Moodle, all 4Cs can now be captured via pre- and post-course self-assessments.

To enhance learner experience and professional teaching practice, the course implemented several creative pedagogy strategies. A learner-centred, inquiry-based approach gave participants space to explore authentic problems and shape their own learning paths. Gamification and digital quests fostered sustained motivation and engagement, while a flipped classroom model encouraged independent exploration of foundational materials before applying knowledge in collaborative sprint projects. These collaborative sprints, which included learning journal prompts to guide critical reflection, challenged learners to devise real-world solutions and articulate their ideas in written form. Teachers focused on building a safe environment for experimentation and failure, giving learners permission to take risks and iterate. Overall, creative pedagogy was embedded not only to engage participants, but to empower them as active agents in addressing global societal challenges with emerging technologies.

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4.2.4 TEAM-based Programs for Environmental Education in a Network of Eco-schools - EASD

The course "Carbon Footprint" was prepared as a pilot project for teachers in the Eco-School programme to use in the classroom with their students (11-17 years old). It consists of 6 sub-topics related to climate change issues and includes different tasks and exercises in a synchronous and asynchronous format. Focusing on carbon footprints within the larger issues of climate change and global warming, this course presented a STEAM-based programme for the Eco-Schools in Serbia. The Eco-Schools network utilises the augMENTOR solution in support of student extracurricular activities, focusing on adaptation and mitigation measures. One of the expressed purposes of this course was to leverage emerging technologies to develop 21st-century skills like the 4Cs. With this in mind, we integrated a Creative Pedagogical approach by doing away with tasks that had predetermined answers in favour of more open-ended ones where students worked collaboratively to define their own solutions. Utilising project-based learning, students were challenged to complete a series of classroom and community-based tasks that asked them to apply and expand their knowledge in varied and authentic ways. Later, students had the opportunity to develop their presentation and communication skills by presenting their project findings in both synchronous and asynchronous formats. Upon completion of each sub-topic, student projects were assessed by teachers using the 4Cs rubrics (Table 2 shows an example of the rubrics used in these assessments.) Teachers also took on a mentoring role, supporting the development of learners' competencies in creativity, collaboration, critical thinking and communication.

Supporting the development of the 4Cs in the "Carbon Footprint" course complies with Serbian Ministry of Education requirements regarding the monthly evaluation of cross-curricular competencies.

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Table 2. *The assessment of green skills*

Assessment Green skills Creativity	Motivation (willingness, Green mindset)	Creativity (cognitive and meta-cognitive skills and competencies)	Behavior (creative process engagement, get inspired, share, and act)
Green, environmental goals and values	• show willingness and curiosity to learn about environmental and climate change problems, collecting information from different sources and media, by focusing on the carbon footprint • use listening, reading, and writing skills to communicate environmental and climate change problems, demonstrating critical thinking on carbon footprint • propose creative green solutions and participate in peer interaction using own technology literacy (online and in person)	• use problem-solving skills to analyze, interpret and understand the need for changes • use creativity to suggest original low-carbon solutions (impact and minimization of carbon footprint); • use creative risk-taking although some solutions cannot be realized immediately with modern technologies	• participate in actions and provide good practices examples related to reducing the carbon footprint, while communicating with peers and adults • use teamwork skills and initiates initiatives to raise environmental awareness • show self-awareness to become a conscious citizen from local, national, and global perspectives (implement what has learned about climate change and carbon footprint in everyday life)

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5 Recommendations for integrating creative pedagogy in AI-supported systems

This section translates the conceptual framework (Sections 3 and 4), instructional design model (Section 5.1), and pilot outcomes (Section 5.2) into concrete, actionable recommendations for key stakeholder groups. The recommendations are grounded in the ADDIE methodology and aligned with the EU and OECD frameworks discussed in Section 3.3, ensuring relevance across policy, practice, and technical development domains. In order to facilitate the actionability of the recommendation, we considered these recommendations from the perspective of the *educators* (related mostly to the decision-making on the integration of genAI and the creative role of AI), the *developers* (recommendations aiming to raise their awareness of the support of AI technologies to the teachers' and learners' agency), and the *policy-makers*, who have the potential to integrate a creative perspective in the use of AI when defining the frameworks that support educational orientations and guide changes in the educational system and curriculum.

5.1 Educators

Educators should be at the heart of the decision-making on the integration of creative pedagogies and the role of AI in the support of the learning and teaching activities. We propose five key recommendations for the educators.

- **Recommendation E1:** Develop personal AI and data literacy. Ongoing professional development in AI is essential for educators to effectively integrate and use AI tools. As described in the AI4T and AI-Pioneers projects (Section 4.1), teacher training must emphasise ethical, creative, and critical uses of AI.
- **Recommendation E2:** Embed Creative Pedagogy in instructional practice. As outlined in Section 3.2, combining creative teaching, teaching for creativity, and creative learning fosters learner autonomy and deeper engagement (Cremin and Chappell, 2021; Leroy and Romero, 2022).
- **Recommendation E3:** Actively engage with AI while retaining pedagogical control. Educators should regard AI as a supportive partner with inherent strengths and challenges. As noted in Section 3.4, AI is a tool whose effectiveness depends on the pedagogical expertise of the teacher (Yannier, 2024; Kasepalu et al., 2022).

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- **Recommendation E4:** Promote open-ended, inquiry-based, learner-driven tasks. Section 4.3 and the pilot experiences (e.g., UPATRAS and IASIS) show how scenario-based and problem-centred designs enhance students' creativity and critical thinking.
- **Recommendation E5:** Use 4Cs rubrics for formative assessment. The rubrics provided in Annex A can be used not only for evaluation but also for student reflection and goal setting (Section 5.3).
- **Recommendation E6:** Apply these recommendations over the full breadth of a student's academic career, with activities that span the full range of K12 participation. Transversal competencies, such as the 4Cs, are developed over time requiring a longitudinal approach to both teaching and assessment (See D4.3).

5.2 Developers

AI developers should not only consider the computer science perspective, but also the implications on tools that support or hinder educational actors' agency (Frøsig & Romero, 2024). We focus our developer recommendations into five points.

- **Recommendation D1:** Align AI systems with Creative Pedagogy principles. AI tools should not replace but rather augment pedagogical frameworks. As emphasised in Section 3.4, CP acts as the "driver's knowledge, maps, and safety rails" that guide AI use toward learner-centred, ethical, and creative outcomes (Habib et al., 2025; Beghetto and Zamana, 2025).
- **Recommendation D2:** Co-collaborate with educators and learners in the development of AI tools for educational contexts. The ADDIE model used in the augMENTOR solution (Section 5.1) illustrates how co-construction with stakeholders leads to more context-relevant and effective instructional designs (Hayes, 2003).
- **Recommendation D3:** Prioritise transparency and ethical AI tools and models. Developers should make how AI-driven suggestions are generated visible to help educators and learners critically engage with system recommendations. This aligns with the concerns about algorithmic bias and ethical issues raised by Habib et al. (2025) and Wu et al. (2024).
- **Recommendation D4:** Support multimodal and interdisciplinary learning. Developers should embed functionality that supports various creative expressions

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and cross-disciplinary content, as exemplified by the Generation AI and AI-Teach projects reviewed in Section 4.1.

- **Recommendation D5:** Incorporate formative assessment and reflection. Tools should integrate scaffolding that supports iterative learning and metacognition. This approach is aligned with the double-loop learning strategies discussed in Section 5.1 and the work of Romero (2024) on metacognitive and computational thinking development.

5.3 Policy-makers

Policy-makers are key actors in defining the frameworks that support educational orientations and guide changes in the educational system and curriculum. The key recommendations for policymakers are organised in five points.

- **Recommendation P1:** Integrate CP and 4Cs into education policy frameworks. Creativity and the 4Cs are central to the EU's Key Competences for Lifelong Learning (Europaea, 2018) and OECD's AI Literacy Framework (OECD, 2025). These should inform national curricula and teacher education.
- **Recommendation P2:** Support funding for teacher OPD in AI-enhanced CP. As shown in AI4T and AI-Teach, educator empowerment is key to effective technology integration (Section 4.1). Targeted investments are necessary to scale these efforts in line with the rapid development of AI advancements.
- **Recommendation P3:** Mandate standards for AI in education. AI tools should adhere to ethical and pedagogical standards, including transparency, inclusion, and learner-centred design, as emphasised in Sections 3.3 and 4.2 (Wu et al., 2024; Habib et al., 2025).
- **Recommendation P4:** Incentivise innovative, inclusive learning environments. Policies should support platforms and practices that promote participatory, creative, and interdisciplinary learning, in alignment with UNESCO's Education for Sustainable Development and OECD's Future of Education and Skills 2030 (UNESCO, 2019; OECD, 2025).
- **Recommendation P5:** Encourage equitable AI integration. Policies should ensure that AI-supported creative learning opportunities are accessible across socio-economic and cultural contexts. Pilot studies like IASIS and KTU underscore the value of inclusive, profession-specific implementations (Section 5.2).

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Table 3. *Framework for Integrating Creative Pedagogy and AI to Foster the 4Cs*

Component	Sub-Element	Recommendations	Supporting Evidence
1. Pedagogical Alignment	1.1 Creative Pedagogy Framework	Integrate the three CP dimensions (creative teaching, teaching for creativity, creative learning) across the learning design process.	Cremin & Chappell (2021); Section 3.2 of D4.2
	1.2 AI as Pedagogical Tool	Use AI to support CP-based design, ensuring learner-centred outcomes.	Section 3.4; Habib et al. (2025); Beghetto & Zamana (2025)
	1.3 Instructional Co-Design	Apply ADDIE and UbD models, including teachers and learners in design phases.	Section 5.1; Hayes (2003); Wiggins & McTighe (2012)
2. Technological Development	2.1 Transparent AI Design	Make AI outputs interpretable for educators and learners to promote agency.	Habib et al. (2025); Wu et al. (2024); Section 4.2
	2.2 Multimodal Learning Tools	Enable creative expression across diverse modalities (visual, textual, media-based).	AI-Teach; Generation AI; Section 4.1
	2.3 Feedback-Driven Adaptivity	Embed formative AI feedback systems aligned with CP and 4Cs rubrics.	Section 5.1; Co-create scale; double-loop learning (Romero, 2024)

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3. Educator Empowerment	3.1 Professional Development in AI & CP	Offer training in AI literacy and pedagogical frameworks that emphasize creativity, ethics, and learner-centred strategies.	AI4T; AI-Pioneers; Section 4.1
	3.2 Teacher-Led AI Integration	Encourage teachers to shape how AI is used in the classroom, not just how it is implemented.	Kasepalu et al. (2022); Frøsig & Romero (2024); Section 3.4
	3.3 Use of 4Cs Rubrics for Assessment	Employ adapted 4Cs rubrics (Annex A) as both evaluative and reflective tools.	Section 5.3; Annex A
4. Policy & Governance	4.1 Standards for AI in Education	Develop certification criteria ensuring AI tools align with CP and 4Cs principles.	OECD (2025); UNESCO (2019); Section 3.3
	4.2 Funding and Scaling of CP+AI Initiatives	Prioritize funding for teacher-led, interdisciplinary, and creative AI-enhanced programs.	EU Key Competences Framework (Europaea, 2018); Section 4.1
	4.3 Inclusive and Equitable Access	Ensure all learners—across demographics and contexts—have access to CP-integrated AI tools.	IASIS and KTU pilots (Section 5.2); UNESCO SDG4
5. Learner Experience	5.1 Inquiry-Based and Open-Ended Tasks	Design tasks that are interdisciplinary, reflective, and student-driven.	Kong et al. (2024); Lucas et al. (2023); Section 3.2.2

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	5.2 Metacognitive and Ethical Reflection	Foster students' critical thinking about AI use, creativity, and collaboration through structured reflection activities.	Habib et al. (2025); Wu et al. (2024); Section 4.2
	5.3 Empowerment Through Agency	Position learners as co-designers of their learning paths, with real-time feedback and visible progress tracking.	Frøsig & Romero (2024); Leroy & Romero (2022); ADDIE model in Section 5.1

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Annex A - 4Cs Assessment Rubrics

We adopted the following rubrics from the EASD Eco-Schools pilot. This decision will allow us to integrate our dataset with forthcoming pilot data and facilitates future comparative analysis. It can also help us generate cross-contextual insights as to how AI tools, at large, can foster the 4Cs across different learning scenarios.

Creativity Rubric (Nice Study)

Creativity components	*Level 1*	*Level 2*	*Level 3*	*Level 4*
	0.25	0.5	0.75	1
Novelty	Lack of capacity to develop novel ideas for eco-schools	Limited capacity to develop novel ideas for eco-schools	Good capacity to develop novel ideas for eco-schools	Excellent capacity to develop novel ideas for eco-schools
Effectiveness	Lack of capacity to develop an effective strategy for innovating in eco-schools	Limited capacity to develop an effective strategy for innovating in eco-schools	Good capacity to develop an effective strategy for innovating in eco-schools	Excellent capacity to develop an effective strategy for innovating in eco-schools
Implementability	Lack of potential for the implementability of the innovation ideas in eco-schools	Limited potential for the implementability of the innovation ideas in eco-schools	Good potential for the implementability of the innovation ideas in eco-schools	Excellent potential for the implementability of the innovation ideas in eco-schools
Creative problem-solving	Lack of problem-solving skills to analyze, interpret and understand the need for changes	Limited problem-solving skills to analyze, interpret and understand the need for changes	Good problem-solving skills to analyze, interpret and understand the need for changes	Excellent problem-solving skills to analyze, interpret and understand the need for changes
Carbon footprint	Lack of creativity to suggest original low-carbon solutions (impact and minimization of carbon footprint)	Limited creativity to suggest original low-carbon solutions (impact and minimization of carbon footprint)	Good creativity to suggest original low-carbon solutions (impact and minimization of carbon footprint)	Excellent creativity to suggest original low-carbon solutions (impact and minimization of carbon footprint)
Risk-taking	Lack of creative risk-taking although some solutions cannot be realized immediately with modern technologies	Limited creative risk-taking although some solutions cannot be realized immediately with modern technologies	Good creative risk-taking although some solutions cannot be realized immediately with modern technologies	Excellent creative risk-taking although some solutions cannot be realized immediately with modern technologies

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Critical Thinking Rubric (Nice Study)

Critical thinking components	*Level 1*	*Level 2*	*Level 3*	*Level 4*
	0.25	0.5	0.75	1
Grasping the components of an idea	Lack of capacity to grasp the different components of problem-solving skills	Limited capacity to grasp the different components of problem-solving skills	Good capacity to grasp the different components of problem-solving skills	Excellent capacity to grasp the different components of problem-solving skills
Exploring different perspectives	Lack of capacity to explore different perspectives of problem-solving skills	Limited capacity to explore different perspectives of problem-solving skills	Good capacity to explore different perspectives of problem-solving skills	Excellent capacity to explore different perspectives of problem-solving skills
Developing a critical opinion	Lack of capacity to develop a critical opinion of problem-solving skills	Limited capacity to develop a critical opinion of problem-solving skills	Goodcapacity to develop a critical opinion of problem-solving skills	Excellent capacity to develop a critical opinion of problem-solving skills

Collaboration Rubric (Nice Study)

Collaboration components	*Level 1*	*Level 2*	*Level 3*	*Level 4*
	0.25	0.5	0.75	1
Sharing understanding and objectives	Lack of capacity to establish and maintain shared understanding and objectives related to an environmental education program	Limited capacity to establish and maintain shared understanding and objectives related to environmental education program	Good capacity to establish and maintain shared understanding and objectives related to environmental education program	Excellent capacity to establish and maintain shared understanding and objectives related to environmental education program
Taking appropriate action	Lack of capacity to take appropriate action to solve the problem related to an environmental education program	Limited capacity to take appropriate action to solve the problem related to an environmental education program	Good capacity to take appropriate action to solve the problem related to an environmental education program	Excellent capacity to take appropriate action to solve the problem related to an environmental education program
Team organization	Lack of capacity to establish and maintain related to an environmental education program	Limited capacity to establish and maintain related toan environmental education program	Good capacity to establish and maintain related to an environmental education program	Excellent capacity to establish and maintain related to an environmental education program

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Communication Rubric (Nice Study)

Communication components	*Level 1*	*Level 2*	*Level 3*	*Level 4*
	0.25	0.5	0.75	1
Using communication for a range of purposes	Lack of use of communication for supporting an environmental education program	Limited use of communication for supporting an environmental education program	Good use of communication for supporting an environmental education program	Excellent use of communication for supporting an environmental education program
Utilising multiple media according to their effectiveness	Lack of capacity to utilize multiple media according to the effectiveness related to an environmental education program	Limited capacity to utilize multiple media according to the effectiveness related to an environmental education program	Good capacity to utilize multiple media according to the effectiveness related to an environmental education program	Excellent capacity to utilize multiple media according to the effectiveness related toan environmental education program
Communicating effectively in diverse environments	Lack of capacity to communicate effectively in diverse environments for the purposes of an environmental education program	Limited capacity to communicate effectively in diverse environments for the purposes of an environmental education program	Good capacity to communicate effectively in diverse environments for the purposes of an environmental education program	Excellent capacity to communicate effectively in diverse environments for the purposes of an environmental education program

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Annex B - Revision of key references on creative pedagogies for AI supported tools

Title	Authors	Key contributions
Student perspectives on creative pedagogy: Considerations for the Age of AI	Habib et al. (2025)	A qualitative analysis of 391 student reflections from two creativity courses in higher education.
Teacher Artificial Intelligence-Supported Pedagogical Actions in Collaborative Learning Coregulation: A Wizard-of-Oz Study	Kasepalu et al. (2022)	A study focusing on AI assistants and how they enhanced teachers' co-regulation strategies and influenced pedagogical decision-making.
Developing an artificial intelligence literacy framework: Evaluation of a literacy course for senior secondary students using a project-based learning approach	Kong et al. (2024)	A study on how a project-based AI literacy course can improve students' AI understanding, problem-solving, and ethical awareness.
Revolutionising Distance Learning: A Comparative Study of Learning Progress with AI-Driven Tutoring	Möller at al. (2024)	A study investigating how AI assistants affected students taking university distance learning courses
Analyzing K-12 AI education: A large language model study of classroom instruction on learning theories, pedagogy, tools, and AI literacy	Wu et al. (2024)	A study that looked at K12 students' ability to engage with AI within learning contexts where creative pedagogy was limited.

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AI and creative pedagogies: Strengths

Enhanced personalised support was a common strength identified in a number of the included papers. Möller et al. (2024) showed increased learning efficiency through the inclusion of an AI tool in over 40 university distance learning courses, while Kong et al. (2024) reported improved problem-solving ability and ethical understanding for secondary students when AI was combined with a project-based learning (PBL) curriculum. In a study of higher education (HE) students, Habib et al. (2025) reported that the inclusion of AI tools increased student creative confidence, creative skill, and helped them associate these skills to their personal and professional lives. Finally, Wu et al. (2024) reported how the inclusion of creative pedagogies such as PBL and collaborative learning can improve teacher AI literacy and help them develop higher-level AI skills.

AI and creative pedagogies: Weaknesses

Many of the weaknesses reported in the studies revolved around the lack of teacher AI literacy, the potential for deskilling or offboarding, and the need for prerequisite skills prior to AI integrations. Both Habib et al. (2025) and Wu et al. (2024) acknowledge existing issues of algorithmic bias, data privacy, and ethics surrounding the training of LLMs. Kasepalu et al. (2022) reported that expertise played a role when working with an AI assistant in teachers' understanding of coregulation. Kong et al. (2024) highlighted the importance of adapting the pedagogical approach for different grade levels and audiences when integrating AI tools in a learning context.

AI and creative pedagogies: Opportunities

Kong et al. (2024) note how creative pedagogical approaches, when combined with AI tools, can foster interdisciplinary skill development beyond the traditional focus on ICT gains. Möller et al. (2024) highlight how AI-based teaching assistants provide a scalable and cost-effective approach to enhance learning in HE, vocational, and corporate environments. Wu et al. (2024) acknowledge the potential for expanding the use of Situated and Game-Based learning strategies in AI integrated courses to enhance the educational experience. Lastly, integrating AI into creative pedagogy, according to Habib et al. (2025), has the potential to foster students' ability to assess and critically engage with GenAI tools while ensuring that human agency is retained in the creative process.

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AI and creative pedagogies: Threats

The majority of the selected studies highlighted similar threats around the integration of AI in creative pedagogy, which included reinforcing teacher dependencies (Kasepalu et al., 2022), the dangers of deskilling when AI is employed without creative pedagogy (Habib et al., 2025), how the lack of ethics integration could result in students being unable to critically assess biased tools (Wu et al., 2024), and how over-reliance on AI tools could result in the long-term reduction of problem-solving skills (Möller et al., 2024).

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