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Research Article

EduMDAI Ethical Digital Pedagogy Pyramid: A Systematic Human-AI Collaborative Framework for Teaching, Learning and Assessment

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Abstract: *The rapid expansion of artificial intelligence (AI) in education creates opportunities for personalized learning while raising concerns about learner dependence, weakened cognitive agency and ethical decision-making. This study introduces the EduMDAI Ethical Digital Education Pedagogy Pyramid, a pedagogical innovation situated within Stage 2: Facilitating (during teaching and learning) of the overarching EduMDAI Model: Ethical Digital Education Pedagogy Framework. The framework is elaborated through the systematic alignment of three structures: the Cognitive Structure, the Teaching and Learning Implementation Structure, and the Assessment Structure. Its five-phase sequence progresses from 100% Human to 100% Human, Human + AI, Human + AI and, finally, 100% Human. The initial phases develop learners' own knowledge and understanding; the middle phases support AI-assisted exploration, evaluation and product development; and the final phase restores independent reflection and responsibility to humans. The corresponding assessment architecture links diagnostic, formative, process-based, authentic/performance and reflective assessment to the respective phases. The principal outcome of this development is an integrated, platform-independent pedagogical design that clearly distinguishes human cognitive agency from the use of digital tools and positions educators as leaders and AI as a navigator. The framework provides an operational basis for designing observable learning activities and assessment evidence rather than established evidence of effectiveness. Future classroom research should evaluate usability, learning outcomes, critical thinking and responsible AI use. The Pyramid offers a systematic, ethically guided approach to human-AI collaboration in which AI supports rather than replaces human thinking and intelligence.*

1. INTRODUCTION

Artificial intelligence is increasingly involved in generating explanations, ideas, feedback and learning products. Although these functions can expand teaching and learning opportunities,

unstructured use may obscure whether learners genuinely understand, evaluate or produce work independently. This presents a pedagogical design challenge: educators must determine when learners should think without AI, when AI assistance is educationally appropriate, and how responsibility for decisions and assessment evidence remains with humans (Miao & Holmes, 2023; Kasneci et al., 2023). Recent evidence suggests that the educational effects of generative AI depend on pedagogical design and context rather than merely on access to technological tools (Liu & Zhong, 2025; Wang et al., 2025).

The overarching EduMDAI Model organises pedagogical practice into three stages-Planning, Facilitating and Evaluating-connected through continuous improvement. Its core components encompass ethical digital education pedagogy, management or learning management systems, digital technology, artificial intelligence and critical thinking. The innovation discussed here is not a separate overarching model. The EduMDAI Ethical Digital Education Pedagogy Pyramid operationalises Stage 2, Facilitating (during teaching and learning), by specifying the progression of cognitive activities, teaching implementation and assessment.

The framework addresses three interconnected needs. First, learners need protected opportunities to activate prior knowledge and establish foundational understanding before receiving AI-generated suggestions. Second, educators need a coherent sequence for introducing AI as support for inquiry, evaluation and product development without relinquishing pedagogical leadership. Third, assessment must document both the learning process and final products, including ethical reasoning and learners' own reflection (Liu et al., 2025). UNESCO's AI competency framework for students likewise emphasises human-centred thinking, AI ethics and responsible creation (Miao et al., 2024).

Accordingly, this study aims to (i) describe the conceptual design of the Pyramid and its relationship to the EduMDAI framework; (ii) explain its five-phase human–AI teaching sequence and cognitive progression; and (iii) map the assessment purposes and evidence associated with each phase. The paper also identifies potential applications of the innovation and the empirical evaluation required before claims of effectiveness can be made.

2. LITERATURE REVIEW

2.1 Integration of Artificial Intelligence in Digital Education

The emergence of generative artificial intelligence (generative AI) has extended the role of digital technology from delivering materials to generating explanations, feedback, suggestions and learning content. Kasneci et al. (2023) discuss the potential of large language models to support differentiated learning, conceptual explanations and dialogic activities, alongside risks of inaccurate information, bias and user dependence. The benefits of AI therefore cannot be inferred from technological capabilities alone; task suitability, educators' roles and learners' ability to evaluate outputs must also be considered.

A systematic review by Liu and Zhong (2025), adopting the Technological Pedagogical Content Knowledge (TPACK) perspective, underscores the importance of alignment among AI tools, content knowledge and pedagogical strategies. Wang et al. (2025) examine empirical studies of generative AI in pedagogical practice and demonstrate the need to attend to context and implementation design. This literature provides a rationale for the EduMDAI Ethical Digital Education Pedagogy Pyramid to specify explicitly when and why AI should be used rather than assuming that AI must feature in every learning activity.

2.2 Ethical Digital Pedagogy and a Human-Centred Approach

Integrating AI into education raises questions of transparency, privacy, equitable access, information reliability and accountability for decisions. UNESCO guidance by Miao and Holmes (2023)

outlines the need for a human-centred approach to generative AI in education and research. The AI competency framework for teachers by Miao and Cukurova (2024) also identifies ethics, pedagogical judgement and professional development as essential elements of responsible AI use.

Meanwhile, the AI competency framework for students by Miao et al. (2024) emphasises a human-centred orientation, AI ethics and the capacity to engage responsibly with AI systems. Within EduMDAI, these principles translate into a clear allocation of responsibilities: educators establish pedagogical aims and boundaries; learners verify, justify and take ownership of decisions; and AI supports exploration. These ethical principles form the proposed design foundation, rather than evidence that a phased sequence alone can eliminate all risks.

2.3 Cognitive Agency, Critical Thinking and Metacognition

Cognitive agency refers to learners' capacity to direct their own thinking, including constructing understanding, weighing evidence and taking responsibility for conclusions. When AI generates answers rapidly, final products may appear complete even when learners' reasoning processes remain unobservable. Kasneci et al. (2023) caution that educational opportunities offered by large language models must be balanced with the development of learners' own competencies. A review by Liu et al. (2025) of critical thinking in English as a foreign language education likewise highlights the need for teaching strategies that deliberately engage learners in critically evaluating AI suggestions.

Regarding metacognition, Chen and Cheung (2025) report meta-analytic findings showing no statistically significant overall effect on metacognition, although several other learning outcomes showed benefits. This finding does not establish that AI inhibits reflection; rather, it supports the need for explicit, assessable reflective tasks. Accordingly, the EduMDAI Model begins learning with two phases of human cognitive agency and concludes with independent reflection without AI-generated reasoning. The term "100% Human" refers to ownership of cognitive processes, not the absence of digital tools. Digital technologies may therefore still be used during "100% Human" phases.

2.4 Human-AI Collaboration in Teaching and Learning

Meaningful human-AI collaboration requires complementary roles rather than transferring all intellectual work to AI technology. Miao and Holmes (2023) emphasise human oversight and use aligned with educational purposes. Accordingly, AI suggestions should be treated as material to test, compare and refine rather than as unquestionable authority. Educators must also teach learners to identify uncertainty, verify facts and explain why outputs are accepted or rejected.

The EduMDAI Ethical Digital Education Pedagogy Pyramid operationalises these principles through the sequence 100% Human → 100% Human → Human + AI → Human + AI → 100% Human. In Phase 3, AI supports idea exploration and alternative perspectives while learners apply, analyse and evaluate. In Phase 4, learners may draw on AI suggestions to construct knowledge, create authentic products or develop solutions to assigned tasks. Nevertheless, final selection, refinement and justification remain human responsibilities. Thus, the sequence constitutes a pedagogical design hypothesis whose feasibility and effects require testing in authentic contexts.

2.5 Authentic and Process-Based Assessment in the AI Era

Generative AI challenges assessment based solely on final products because generated texts or materials may not fully reflect learners' understanding. A scoping review by Xia et al. (2024) describes how generative AI is transforming higher education assessment practices, highlighting the need to evaluate processes, the authenticity of contributions and task design. Evidence such as learning activity

processes, discussions, observations, decision logs and oral presentations can therefore complement assessment of final products or solutions to assigned problems.

The EduMDAI Assessment Structure aligns diagnostic assessment with Phase 1, formative assessment with Phase 2, process-based assessment with Phase 3, authentic or performance assessment with Phase 4, and reflective assessment with Phase 5. This alignment enables educators to distinguish initial conceptual mastery, the quality of critical interaction with AI, the quality of products or problem-solving, and learners' ability to explain their own learning. Nevertheless, rubric validity, observational reliability and the suitability of instruments for different learner groups still require empirical evaluation.

2.6 The Need for an Integrated Pedagogical Framework in AI-Assisted Education

Existing literature offers important guidance on AI competencies, ethical risks, pedagogical integration and assessment, but these domains are often discussed with different emphases. UNESCO frameworks (Miao & Cukurova, 2024; Miao et al., 2024) articulate competencies and principles of responsibility, while Liu and Zhong (2025) emphasise appropriate AI integration from a TPACK perspective. Daniel et al. (2025) examine the potential of generative AI for academic skills development in higher education. Taken together, these sources support the need for planning that connects technology use with cognitive development and assessment evidence of learning.

As a design response, the EduMDAI Pyramid brings together the Cognitive Structure, Teaching and Learning Implementation Structure, and Assessment Structure within Stage 2: Facilitating of the overarching EduMDAI Model. Its proposed contribution is not the independent invention of critical thinking, human-AI collaboration or authentic assessment, but the organisation of all three within a five-phase sequence with explicit boundaries for cognitive agency. Its relative distinctiveness compared with other frameworks therefore requires dedicated comparative research before definitive claims can be made.

2.7 Literature Synthesis and Research Gap

The literature synthesis identifies three principal considerations. First, the effectiveness of AI use depends on pedagogical alignment rather than tool use alone (Liu & Zhong, 2025; Wang et al., 2025). Second, human oversight, ethics and AI literacy must be embedded in learning activities (Miao & Holmes, 2023; Miao et al., 2024). Third, assessment should capture reasoning, processes and reflection as well as final products (Xia et al., 2024; Chen & Cheung, 2025). Together, these considerations provide a conceptual foundation for designing the EduMDAI Ethical Digital Education Pedagogy Pyramid.

At a conceptual level, the gap addressed by this model is the need for implementation guidance specifying when learners think independently, when AI is used collaboratively and how assessment evidence is collected at each stage. However, this review is not an exhaustive systematic review establishing the absence of similar frameworks. Follow-up research should validate the suitability of the structure through expert review, test classroom implementation readiness and assess effects on critical thinking, autonomy, authentic performance and ethical AI practices. The literature therefore supports the rationale for developing the innovation, while its effectiveness remains an open empirical question. The TPACK framework explains that meaningful technology decisions should integrate technological, pedagogical and content knowledge rather than focus on tools alone (Mishra & Koehler, 2006). DigCompEdu likewise emphasises professional competencies, digital resources, teaching, assessment and learner empowerment (Redecker, 2017). Both provide external rationales for aligning EduMDAI components but do not establish the innovation's effectiveness.

A systematic review by Zawacki-Richter et al. (2019) highlights the importance of educators' perspectives in AI applications in higher education. Long and Magerko (2020) define AI literacy in

terms of competencies for understanding, interacting with and critically evaluating AI. Zimmerman (2002) describes self-regulated learning as a process involving the monitoring and regulation of learning activities. These perspectives support the rationale for EduMDAI's human-led reflection phase.

At the policy level, UNESCO (2021) emphasises ethics and the protection of rights in AI development. UNESCO (2023) cautions that educational technology use should be guided by appropriateness, equity and evidence. OECD (2023) further notes that digital education ecosystems encompass management systems, teaching and learning tools, and the people who use them. The European Commission (2022) provides practical guidelines for educators on the ethical use of AI and data. These documents support human-centred design principles but do not directly validate EduMDAI's five-phase sequence. Guidance from the United States Department of Education (2023) also recommends human oversight in AI use for teaching and learning.

3. OVERARCHING EDUMDAI MODEL FRAMEWORK

The Overarching EduMDAI Model: Ethical Digital Education Pedagogy Framework is a macro-level structure for the teaching cycle that connects three stages: (1) Planning before teaching and learning, (2) Facilitating during teaching and learning, and (3) Evaluating after teaching and learning. Arrows between the stages represent the transition from planning to action, from action to reflection, and from reflection to improved planning. Continuous improvement extends across the entire cycle. Figure 1 illustrates the overarching EduMDAI Model framework.

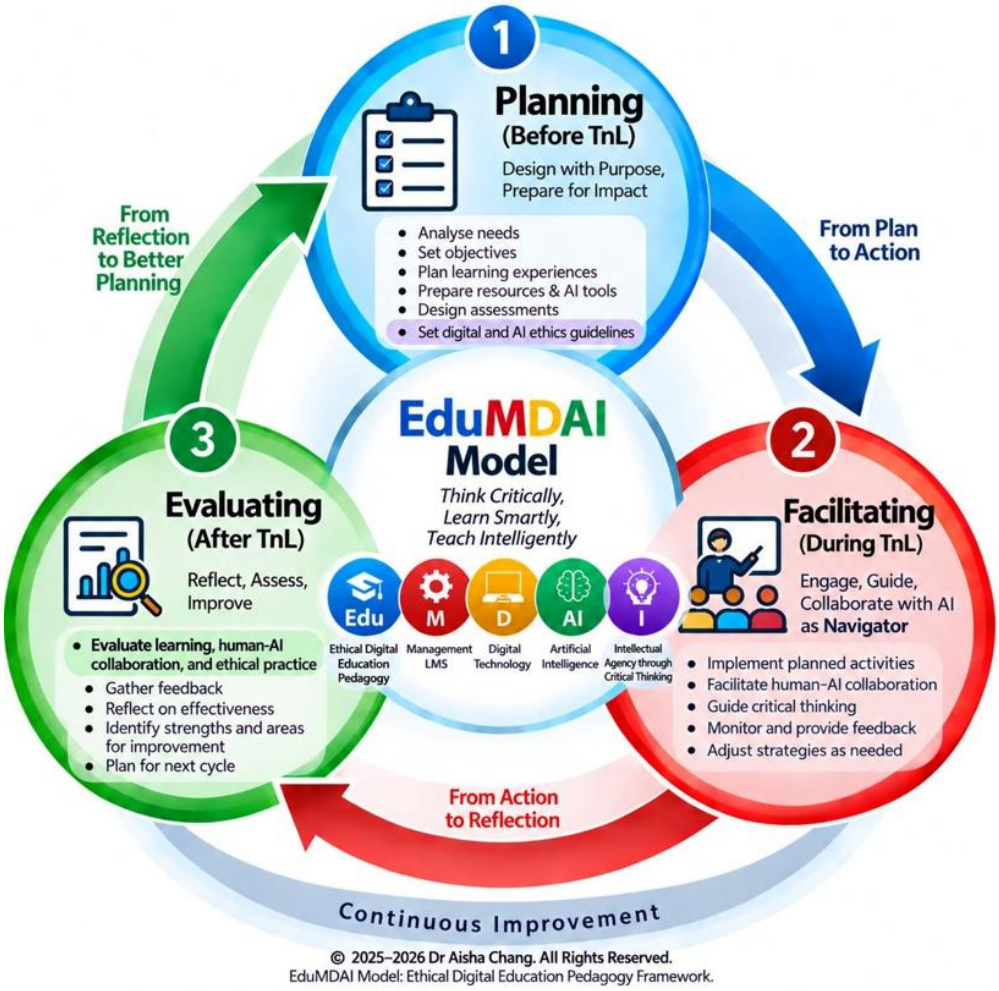


Figure 1. Overarching EduMDAI Model Framework

3.1 Five Core Components

EduMDAI Model integrates five components: Ethical Digital Education Pedagogy, Management/Learning Management Systems, Digital Technology, Artificial Intelligence and Intellectual Agency through Critical Thinking (Chang, 2025).

i. Edu – Ethical Digital Education Pedagogy
ii. M – Management/LMS (management and learning management systems)
iii. D – Digital Technology
iv. AI – Artificial Intelligence
v. I – Intellectual Agency through Critical Thinking

These five components complement one another: pedagogy defines the purpose; management supports coordination; technology provides the environment; AI serves as a navigator; and human intellectual agency preserves critical judgement. The definition of component I is reflected in the accompanying Figure 1.

3.2 Stage 1: Planning (Before Teaching and Learning)

Educators analyse learners' needs, set objectives, plan learning experiences, prepare resources and AI tools, design assessments, and establish digital and AI ethics guidelines. This stage underscores that technology use must begin with a clear pedagogical purpose, consistent with the rationale of TPACK (Mishra & Koehler, 2006) and educators' digital competencies (Redecker, 2017).

3.3 Stage 2: Facilitating (During Teaching and Learning)

Educators implement planned activities, guide human–AI collaboration, promote critical thinking, monitor progress, provide feedback and adapt strategies. At this stage, the EduMDAI Ethical Digital Education Pedagogy Pyramid functions as a specific operational structure organising the five phases: 100% Human → 100% Human → Human + AI → Human + AI → 100% Human. "100% Human" refers to human cognitive agency relative to AI, not the absence of digital tools.

3.4 Stage 3: Evaluating (After Teaching and Learning)

Educators evaluate learning, the quality of human-AI collaboration and ethical practices; gather feedback; reflect on effectiveness; identify strengths and areas for improvement; and plan the next cycle. This stage completes the connection between assessment evidence and pedagogical decisions, consistent with UNESCO's (2023) emphasis on evidence-based technology use.

3.5 Relationship Between the Overarching EduMDAI Model and the Ethical Digital Education Pedagogy Pyramid

The overarching EduMDAI Model addresses when and how the entire teaching and learning cycle is managed, whereas the EduMDAI Ethical Digital Education Pedagogy Pyramid specifies how cognitive agency, AI collaboration and assessment are organised within Stage 2 alone. The Pyramid is therefore neither an independent model nor a replacement for the overarching EduMDAI framework. It is an implementation framework within the Facilitating stage.

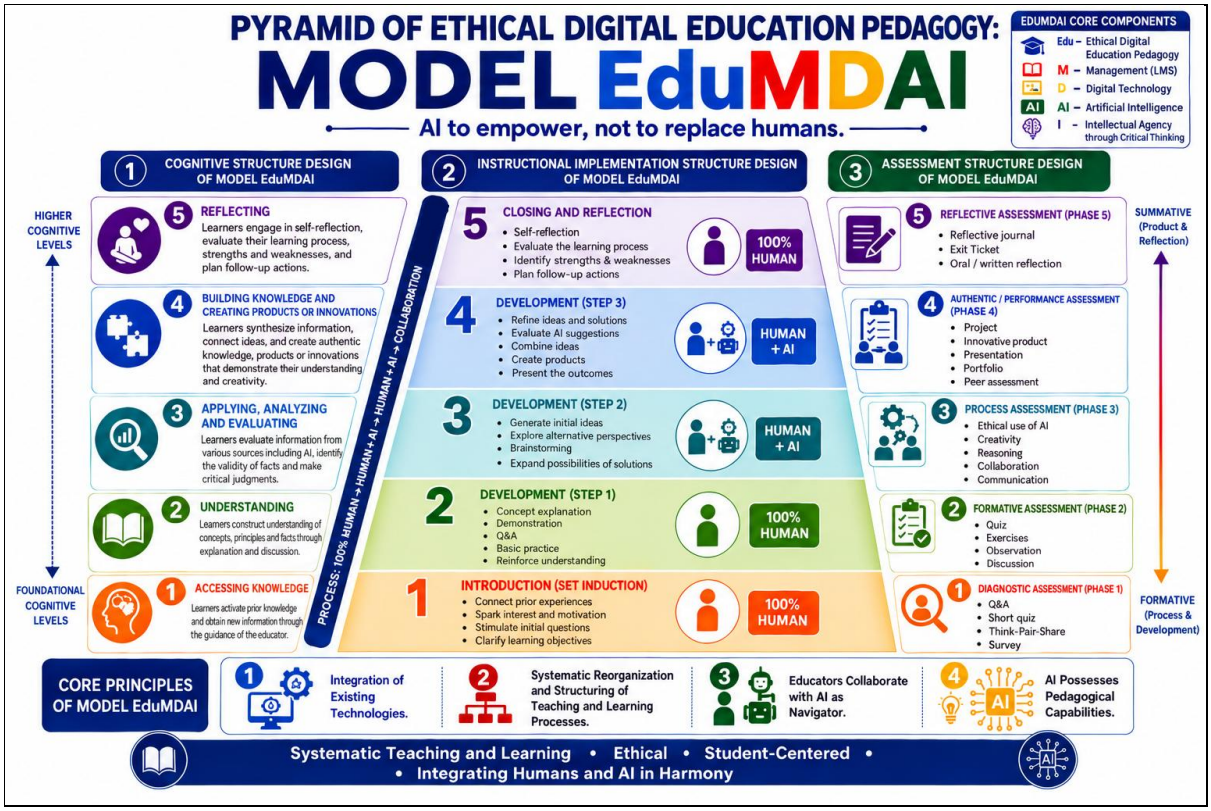


Figure 2. EduMDAI Ethical Digital Education Pedagogy Pyramid

4. METHODOLOGY

4.1 Innovation Design and Development Approach

This section reports the design and specification of a pedagogical innovation rather than an experimental intervention. The source materials document the proposed architecture, phase activities and assessment practices but provide no sample, intervention duration, validation scores or comparative learning outcomes. Accordingly, the development is presented as a conceptual design process involving the definition of a teaching problem, specification of interdependent structures, mapping of five learning phases and alignment of assessment evidence with intended cognitive activities.

Four design principles derived from the overarching EduMDAI Model guide this specification: systematic integration of existing digital technologies; restructuring teaching and learning into a clear sequence; educator–AI collaboration with educators retaining leadership; and recognition that AI has pedagogically useful capabilities but should not replace learners' judgement. The guiding proposition is "AI to empower, not replace humans" (Miao & Cukurova, 2024). This approach is consistent with reviews highlighting the importance of scaffolding and purposeful instructional strategies in AI-assisted learning (Liu & Zhong, 2025).

4.2 Three Integrated Structures

Educators The Cognitive Structure comprises five progressive levels:
(1) Access Knowledge
(2) Understand
(3) Apply, Analyse and Evaluate
(4) Build Knowledge and Produce Products or Problem-Solving Innovations

(5) Reflect

This progression is designed to connect foundational learning with higher-order cognitive activities and metacognitive evaluation. These levels are operational labels specific to the EduMDAI Ethical Digital Education Pedagogy Pyramid and should not be interpreted as a newly validated psychometric taxonomy.

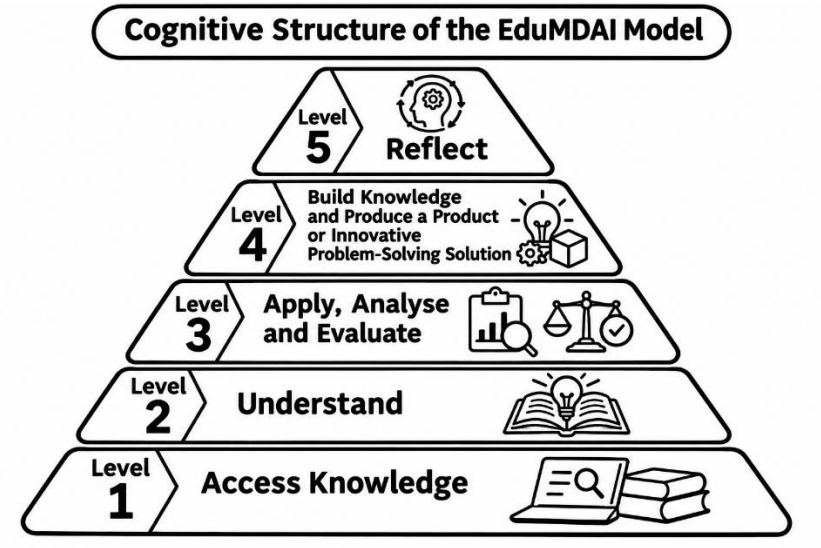


Figure 3. Cognitive Structure of the EduMDAI Model

The Teaching and Learning Implementation Structure establishes a specific pedagogical purpose for each of the five phases. Phase 1, Beginning (Set Induction), activates prior experiences, interests and questions. Phase 2, Development (Step 1), supports conceptual explanations, demonstrations, questioning and reinforcement of foundational understanding. Phase 3, Development (Step 2), introduces AI-assisted brainstorming, alternative perspectives and multiple possibilities. Phase 4, Development (Step 3), involves refining and evaluating suggestions, integrating ideas, and presenting authentic products or solutions to assigned problems. Phase 5, Closure and Reflection, requires learners to evaluate their processes, identify strengths and weaknesses, and plan follow-up actions.

The Assessment Structure aligns Phase 1 with diagnostic assessment, Phase 2 with formative assessment, Phase 3 with process-based assessment, Phase 4 with authentic/performance assessment, and Phase 5 with reflective assessment. Proposed evidence includes short quizzes and Think–Pair–Share; exercises, observations and discussions; observations of ethical AI use, creativity, reasoning, collaboration and communication; projects, products, presentations, portfolios and peer assessment; and reflective journals, exit tickets, or oral/written reflections. This emphasis on varied assessment responds to research documenting changes in higher education assessment practices associated with generative AI (Xia et al., 2024).

4.3 Operational Definition of Human-AI Participation

The five-phase participation pattern is 100% Human → 100% Human → Human + AI → Human + AI → 100% Human. Here, "100% Human" means full human cognitive agency relative to AI, not a prohibition on digital technology. Digital tools may still be used. For example, digital quizzes or exit tickets can be used during 100% Human phases when the tools record or display learners' own thinking rather than generate reasoning or decisions on their behalf. During the two Human + AI phases, learners may examine AI suggestions but remain responsible for verification, selection,

modification and final decisions (Miao & Holmes, 2023). Figure 4 illustrates the Chang HAI-5 Formula, the five-phase human–AI cognitive agency formula for the EduMDAI Teaching and Learning Implementation Structure.

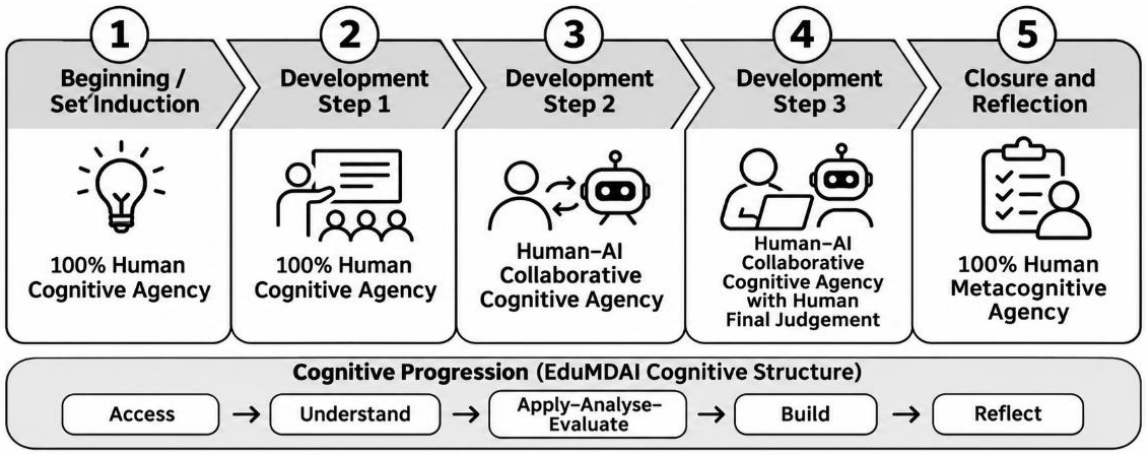


Figure 4. Chang HAI-5 Formula (Five-Phase Human-AI Cognitive Agency Formula for the EduMDAI Teaching and Learning Implementation Structure)

4.4 Proposed Evaluation Techniques

Subsequent pilot studies should assess clarity, feasibility and implementation fidelity through expert review, educator feedback, lesson-plan analysis and structured classroom observations. Learning evidence could be collected using pre-/post-concept tasks, analytic rubrics for critical reasoning and authentic products, guided reflection prompts and AI-use disclosure records. Such data would enable triangulation of observed learner actions, assessed work and participant perceptions. These procedures are proposed for future evaluation and are not reported as having been conducted in the supplied materials (Miao & Cukurova, 2024).

5. FINDINGS AND DISCUSSION

5.1 Development Outcome: A Coherent Teaching Sequence

The principal outcome of this innovation development is a coherent pedagogical specification linking cognition, teaching and learning, and assessment. Rather than treating AI use as continuous or unrestricted, the EduMDAI Ethical Digital Education Pedagogy Pyramid identifies two human-led preparatory phases, two bounded collaborative phases and a final human-led reflective phase. This sequence offers a practical design logic: learners first establish a conceptual foundation, then explore and critically examine AI-supported possibilities, and finally articulate their understanding and next steps independently.

The deliberate return to 100% Human in Phase 5 is an important design feature. It makes reflection an independent cognitive task rather than another AI-generated response. It also allows educators to examine whether learners can justify decisions, recognise limitations and explain what they have actually learned. Whether this sequence improves independent reasoning compared with alternative approaches remains an empirical question (Liu et al., 2025). A meta-analysis found benefits for some learning outcomes but no statistically significant overall effect on metacognition, reinforcing the rationale for explicitly designing reflective activities (Chen & Cheung, 2025).

5.2 Alignment of Learning Activities and Assessment

Table 1 summarises the relationship among cognitive purposes, human-AI participation and assessment in each phase. This alignment is an intended design feature of the EduMDAI Ethical Digital Education Pedagogy Pyramid and is not presented as an experimentally validated outcome.

Table 1. Alignment of EduMDAI Pyramid Phases with Assessment.

Phase	Cognitive Focus	Participation	Assessment Evidence
1	Access knowledge	100% Human	Diagnostic: questioning, short quizzes, Think-Pair-Share and other relevant diagnostic assessment activities.
2	Understand	100% Human	Formative: exercises, observation, discussion and other relevant assessment activities.
3	Apply, analyse, evaluate	Human + AI	Process-based: ethical AI use, reasoning, collaboration and other relevant learning processes.
4	Build knowledge / produce products	Human + AI	Authentic/performance: projects, products, portfolios and other relevant performance-based assessment activities.
5	Reflect	100% Human	Reflective: journals, exit tickets, oral/written reflection and other relevant reflective assessment activities.

In practice, this alignment enables educators to specify what learners should demonstrate before, during and after AI collaboration. In Phase 3, for example, evidence should extend beyond the number of ideas generated to include how learners evaluate suggestions, communicate reasoning and observe ethical boundaries. In Phase 4, authentic products can be assessed alongside learners' explanations of why particular AI suggestions were accepted, modified or rejected.

5.3 Distinctive Features, Applications and Limitations

The distinctive contribution of the EduMDAI Ethical Digital Education Pedagogy Pyramid lies in its integrated sequence, not in a claim that human–AI collaboration, reflective learning or formative assessment is individually novel. The Pyramid combines explicit boundaries for AI participation, progressively developing cognitive purposes and aligned assessment within a single teaching architecture. It is designed to be platform-independent: educators can adapt tasks to face-to-face, blended or virtual environments without requiring a particular AI application or learning management system (Kasneci et al., 2023; Miao & Cukurova, 2024).

Potential users include lecturers, schoolteachers, instructional designers and professional development providers who need consistent guidance for lesson planning and ethical AI integration. Practical implementation requires age-appropriate task design, access arrangements, transparent expectations for AI use and assessment rubrics that recognise learners' original contributions. Adaptation is especially important when learners have unequal access to AI tools or different levels of digital literacy. A systematic literature review also identifies opportunities for developing cognitive and interpersonal skills while emphasising responsible implementation (Daniel et al., 2025).

Several limitations must nevertheless be acknowledged. The supplied documentation establishes the existence of a proposed architecture and illustrative activities but does not substantiate claims concerning adoption rates, achievement gains, learner satisfaction, reliability, expert consensus or commercial demand. Consequently, propositions concerning effectiveness, scalability and transferability remain hypotheses for future investigation. Independent review and classroom studies across subjects and learner groups are needed to determine whether the intended cognitive and ethical safeguards operate as designed (Liu et al., 2025).

6. CONCLUSION

The EduMDAI Ethical Digital Education Pedagogy Pyramid translates Stage 2: Facilitating (during teaching and learning) of the overarching EduMDAI framework into a structured, human-centred approach to teaching, learning and assessment. Its three interconnected structures and five-phase sequence clarify when human cognitive agency should be preserved, when AI may assist exploration and product development, and how assessment can document processes and reflection. At present, the innovation's contribution is a clearly articulated pedagogical design rather than demonstrated causal improvements in learning.

Future studies should include expert validation, pilot implementation, implementation-fidelity checks and comparative evaluation of critical thinking, learner autonomy, authentic performance and ethical AI practices. Potential dissemination channels include educator training modules, lesson-planning templates, assessment instruments and institutionally licensed professional learning resources, subject to validation, intellectual property review and market evaluation. The central proposition remains that AI should empower rather than replace human intelligence (Miao & Holmes, 2023).

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