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DEVELOPING UNIVERSITY STUDENTS' INDEPENDENT THINKING AND ACADEMIC RESPONSIBILITY COMPETENCIES THROUGH THE USE OF GENERATIVE ARTIFICIAL INTELLIGENCE TECHNOLOGIES IN HIGHER EDUCATION

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Abstract. This article examines the development of university students' independent thinking, critical analysis, and academic responsibility competencies through the pedagogically purposeful and responsible use of generative artificial intelligence technologies. In contrast to approaches based either on prohibiting generative AI or allowing its unrestricted use, an integrative pedagogical model is proposed that preserves the primacy of human intellectual activity and human decision-making.

Within the proposed model, student interaction with artificial intelligence is organized through the sequential stages of **problem formulation - initial independent reasoning - interaction with AI - verification against reliable sources - comparison of alternative viewpoints - critical evaluation - independent decision-making - academic responsibility - reflection**.

A system of criteria is developed for assessing students' independent thinking and academic responsibility. It includes cognitive, analytical-critical, information-verification, academic-ethical, and reflective components.

An integrative competency index based on normalized indicators is proposed for comprehensive assessment. The model conceptualizes generative artificial intelligence not as a substitute for human thinking but as a pedagogical tool capable of strengthening students' independent intellectual activity when used within a properly designed educational framework.

Keywords: generative artificial intelligence, higher education, independent thinking, critical thinking, academic responsibility, academic integrity, AI competency, digital pedagogy, verification, reflection, pedagogical model.

Introduction. The rapid development of digital technologies is exerting a profound influence on the content, methods, and organization of higher education. In particular, generative artificial intelligence systems capable of automatically producing text, images, software code, analytical information, and other intellectual products are changing traditional models of learning and teaching.

The emergence of generative AI expands the conventional relationship between the teacher and the student toward a new dynamic involving the **teacher, artificial intelligence, and learner**. Contemporary AI competency frameworks emphasize a human-centered approach, AI ethics, understanding of AI technologies, responsible application, and the preservation of human agency in educational environments [1-3].

However, the presence of generative AI in education does not automatically improve learning quality. When cognitive tasks are excessively delegated to AI, students may reduce their own intellectual effort, metacognitive engagement, source verification, and independent decision-making. By contrast, pedagogically structured interaction with generative AI can support critical thinking, argumentation, creativity, problem solving, and reflective learning [4].

Recent research also demonstrates the dual nature of generative AI in higher education. It can increase accessibility, productivity, feedback quality, and learner engagement, while simultaneously creating risks related to academic integrity, uncritical acceptance of generated information, misinformation, and excessive cognitive dependence on AI systems [5-11].

Therefore, the central pedagogical problem is not simply:

“How can students be taught to use artificial intelligence?”

Rather, it is:

“How can students remain independent thinkers who assume responsibility for their academic decisions even when powerful artificial intelligence tools are available?”

RESEARCH AIM

The aim of the study is to develop an integrative pedagogical model for fostering university students’ independent thinking and academic responsibility through the purposeful use of generative artificial intelligence and to substantiate criteria for evaluating the effectiveness of this model.

RESEARCH OBJECTIVES

The study is intended to:

1. analyze the pedagogical opportunities and risks of generative AI in higher education;
2. determine the relationship between independent thinking and academic responsibility;
3. develop a pedagogical algorithm for student-AI interaction;

4. identify the structural components of independent thinking and academic responsibility competency;

5. formulate criteria and indicators for competency assessment;

6. propose an integrative competency index;

7. develop a mechanism for experimental verification of the proposed pedagogical model.

1. PEDAGOGICAL NATURE OF GENERATIVE ARTIFICIAL INTELLIGENCE

Generative artificial intelligence can be considered from two fundamentally different pedagogical perspectives.

In the first approach, AI functions primarily as a **technology for producing a ready-made result**:

$$\text{Task} \rightarrow \text{AI} \rightarrow \text{ready-made answer}$$

Under such a model, the student’s independent intellectual participation may decrease.

In the second approach, AI functions as an **intellectual partner that stimulates the learner’s reasoning**:

$$\boxed{\text{Problem} \rightarrow \text{Dialogue with AI} \rightarrow \text{Verification} \rightarrow \text{Analysis} \rightarrow \text{Independent decision}}$$

The present study is based on the second approach.

From this perspective, generative AI should not become the final decision-maker. Its pedagogical role is to provide information, alternatives, arguments, counterarguments, and intellectual stimuli that subsequently undergo human verification and critical evaluation.

2. THE “HUMAN - AI - HUMAN” PEDAGOGICAL PRINCIPLE

The central principle of the proposed model can be expressed as:

$$\boxed{H_1 \rightarrow AI \rightarrow H_2}$$

where:

H_1 - initial human understanding of the problem and formulation of an initial position;

AI - information, alternatives, or analytical assistance obtained through interaction with artificial intelligence;

H_2 - the final decision independently verified, analyzed, and accepted by the human learner.

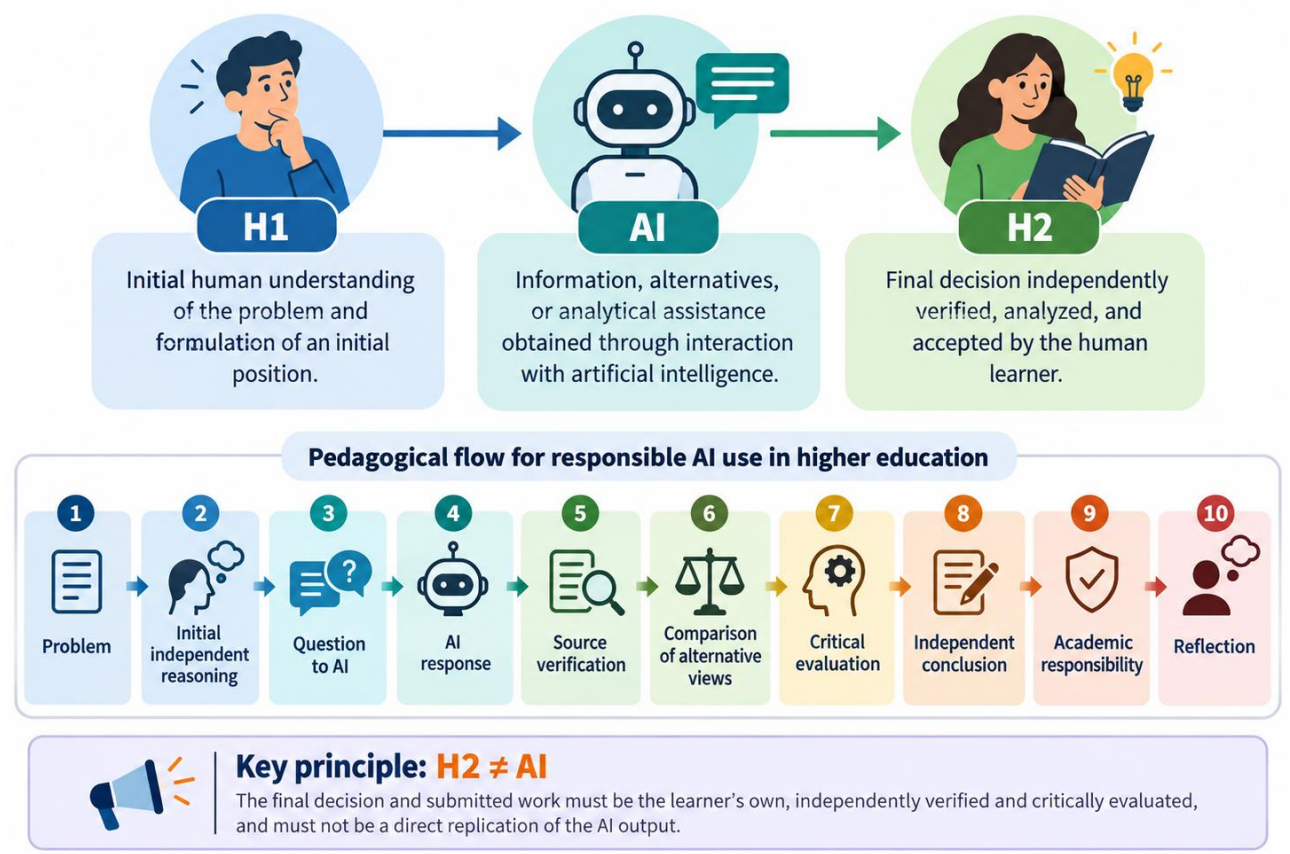
A fundamental requirement of the model is:

$$H_2 \neq AI$$

This condition means that the student’s final intellectual product should not simply reproduce the AI-generated response.

Instead, it should represent the result of the student’s own analysis, verification, comparison, interpretation, and judgment.

Figure 1. Responsible Use of Generative Artificial Intelligence: The “Human - AI - Human” Pedagogical Model.



The complete sequence is:

Problem → Initial independent reasoning → Question to AI → AI response → Source verification → Comparison of alternative views → Critical evaluation → Independent conclusion → Academic responsibility → Reflection

3. INTEGRATIVE MODEL OF INDEPENDENT THINKING AND ACADEMIC RESPONSIBILITY

The proposed approach treats independent thinking and academic responsibility not as isolated abilities but as mutually connected components of an integrative competency.

The model can be represented as:

$$C_{\text{IMA}} = f(C_K, C_T, C_V, C_A, C_R)$$

where:

C_K - cognitive competency;

C_T - analytical-critical competency;

C_V - verification competency;

C_A - academic and ethical responsibility;

C_R - reflective competency.

Table 1. Components of the Integrative Competency

№	Component	Content	Main indicator
	Cognitive	Independent understanding of the	Understanding concepts and

1		problem	relationships
2	Analytical-critical	Critical analysis of AI-generated responses	Comparing arguments and evidence
3	Verification	Checking the reliability of information	Comparison with reliable sources
4	Academic responsibility	Respect for authorship and academic standards	Transparent disclosure of AI use
5	Reflective	Evaluation of one’s own thinking process	Recognition and correction of errors

The combination of these five components constitutes the proposed **independent thinking and academic responsibility competency**.

4. PROPOSED PEDAGOGICAL ALGORITHM

The student’s interaction with generative AI is organized through eight successive stages.

Stage 1. Independent understanding of the problem

Before activating an AI system, the learner should independently analyze the problem and identify its essential features.

Stage 2. Formulation of an initial hypothesis

The learner’s initial position is recorded as:

$$H_0 = \text{Student's initial hypothesis}$$

This step is important because it makes it possible to distinguish the student’s original reasoning from ideas subsequently introduced by AI.

Stage 3. Pedagogically appropriate questioning of AI

The prompt should be formulated so that AI does not simply complete the entire task but instead provides material for analysis, comparison, or further reasoning.

Stage 4. Decomposition of the AI response

The generated response should be divided into:

- factual statements;
- interpretations;
- hypotheses;
- explanations;
- claims requiring external verification.

Stage 5. Verification

Important AI-generated claims should be checked against independent and reliable sources.

A verification coefficient is proposed:

$$K_v = \frac{N_t}{N_u}$$

where:

$\mathbf{N_t}$ - number of verified claims;

$\mathbf{N_u}$ - total number of claims requiring verification.

The desirable condition is:

$$\boxed{K_v \to 1}$$

A value approaching one indicates that almost all claims requiring verification have actually been checked.

Stage 6. Critical evaluation

The learner asks questions such as:

Why should this claim be accepted?

What evidence supports it?

Are alternative explanations possible?

Under what conditions could the conclusion be incorrect?

Stage 7. Independent decision-making

The student’s final decision can be represented as:

$$\boxed{D_s = f(H_0, A_i, S, V, R)}$$

where:

$\mathbf{D_s}$ - the student’s independent decision;

$\mathbf{H_0}$ - initial hypothesis;

$\mathbf{A_i}$ - AI-provided information;

S - scientific sources;

V - verification results;

R - reflective analysis.

Stage 8. Academic reflection

At the end of the task, the student explains:

where AI was used, which AI-generated statements were rejected, which claims were verified, and how the final conclusion was reached.

5. A NEW INTERPRETATION OF ACADEMIC RESPONSIBILITY IN THE AGE OF AI

In a generative-AI environment, academic responsibility cannot be reduced merely to the avoidance of plagiarism.

It should include several interconnected dimensions:

$$\boxed{AM = H + M + V + J + R}$$

where:

H - honesty;

M - responsibility for authorship;

V - verification;

J - transparent disclosure of AI use;

R - personal responsibility for the final academic result.

Thus, the learner remains responsible even when part of the informational or analytical support has been provided by an AI system.

AI cannot assume academic responsibility on behalf of the student.

6. THE AI-CRITICAL THINKING CYCLE

The proposed intellectual cycle can be represented as:

$$C \rightarrow A \rightarrow V \rightarrow T \rightarrow Q \rightarrow D \rightarrow R$$

where:

C - formulation of the question;

A - AI response;

V - verification;

T - analysis;

Q - alternative questions or counterpositions;

D - independent decision;

R - reflection.

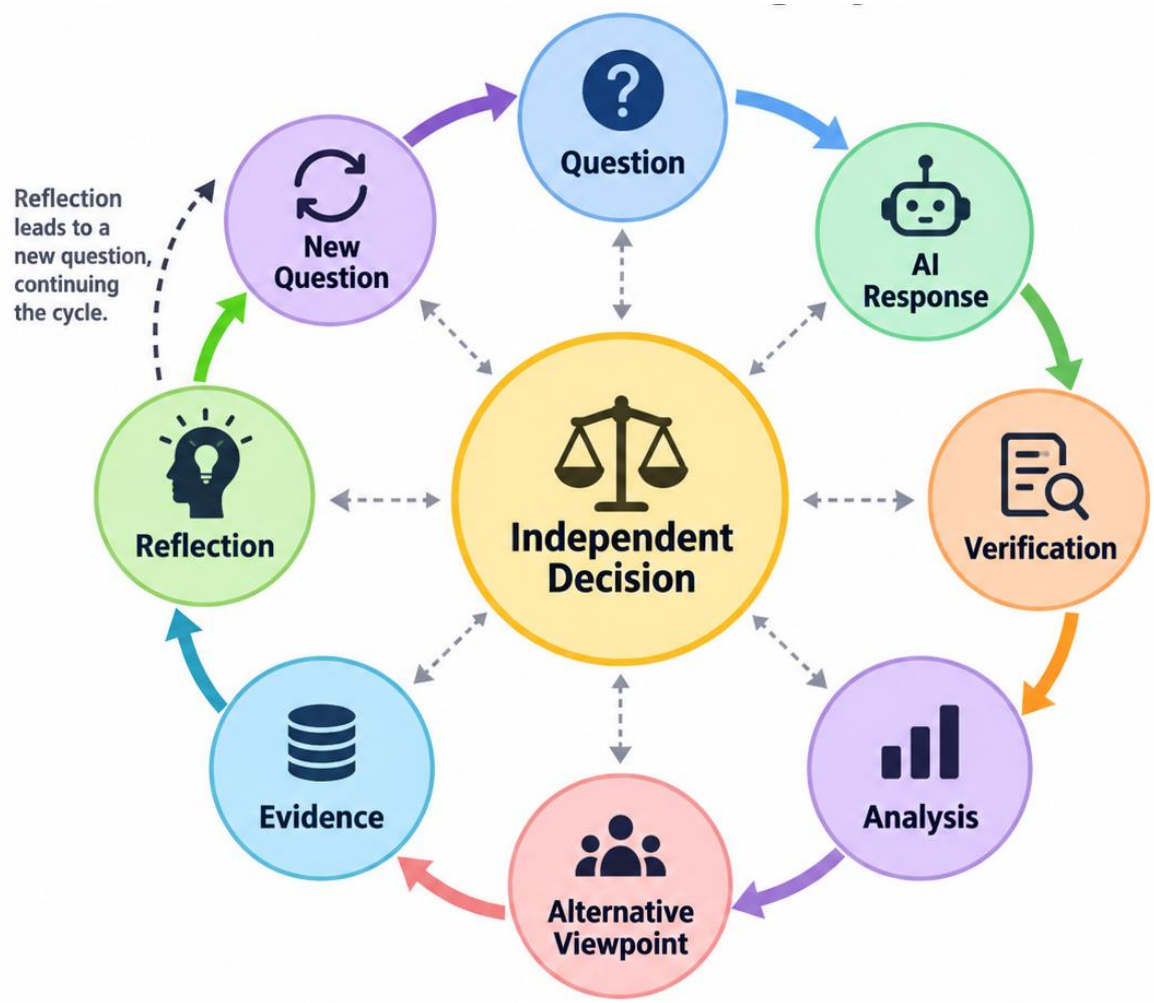
The cycle is not necessarily completed only once.

Reflection may generate a new question:

$$R \rightarrow C_2$$

Therefore, interaction with AI becomes an **iterative intellectual process**.

Figure 2. AI-Critical Thinking Cycle.



At the center of the cycle is the **INDEPENDENT DECISION**, surrounded by:

Question → AI response → Verification → Analysis → Alternative viewpoint → Evidence → Reflection → New question

7. ASSESSMENT CRITERIA

Five principal indicators are proposed for assessing competency:

X_1 - independent understanding of the problem;

X_2 - critical analysis;

X_3 - information verification;

X_4 - academic responsibility;

X_5 - reflection.

Each indicator may be assessed on a 0-100 scale.

The normalized indicator is:

$$x_i = \frac{X_i}{100}$$

Therefore:

$$0 \le x_i \le 1$$

8. INTEGRATIVE COMPETENCY INDEX

A general integrative index is proposed:

$$I_{\text{IMA}} = w_1x_1 + w_2x_2 + w_3x_3 + w_4x_4 + w_5x_5$$

where the weighting coefficients satisfy:

$$w_1 + w_2 + w_3 + w_4 + w_5 = 1$$

If all components are assigned equal importance:

$$w_1 = w_2 = w_3 = w_4 = w_5 = 0.2$$

then:

$$I_{\text{IMA}} = 0.2(x_1 + x_2 + x_3 + x_4 + x_5)$$

Table 2. Provisional Competency Levels

№	Integrative index	Level	Interpretation
1	**0.00-0.39**	Low	Strong dependence on AI-generated responses
2	**0.40-0.59**	Moderate	Partial independent analysis
3	**0.60-0.79**	Sufficient	Stable critical analysis and verification
4	**0.80-1.00**	High	Independent, evidence-based, and responsible activity

These thresholds are **provisional** and should be validated or refined using expert assessment and pilot experimental data before being treated as empirical standards.

9. AI INTELLECTUAL-DEPENDENCE COEFFICIENT

An additional diagnostic indicator is proposed:

$$K_{AI} = \frac{N_{AI}}{N_{\text{total}}}$$

where:

N_{AI} - number of cognitive operations directly delegated to AI;

N_{total} - total number of cognitive operations required by the task.

The goal of effective AI-supported education is not necessarily:

K_{AI} - because such a condition would imply almost complete non-use of AI.

Instead, the desirable principle is:

$$K_{AI} = K_{\text{rational}}$$

where **$K_{rational}$** denotes a pedagogically justified level of AI use.

In such a situation, AI supports the learner’s thinking without replacing the learner’s essential cognitive activity.

10. METHODOLOGY FOR ORGANIZING THE PEDAGOGICAL EXPERIMENT

To evaluate the proposed model, students may be divided into two groups:

Control Group (CG) - instruction based primarily on the conventional methodology;

Experimental Group (EG) - instruction based on the responsible AI-critical-thinking model.

The experimental design follows:

$$T_0 \rightarrow T_1$$

where:

T_0 - baseline diagnostic assessment;

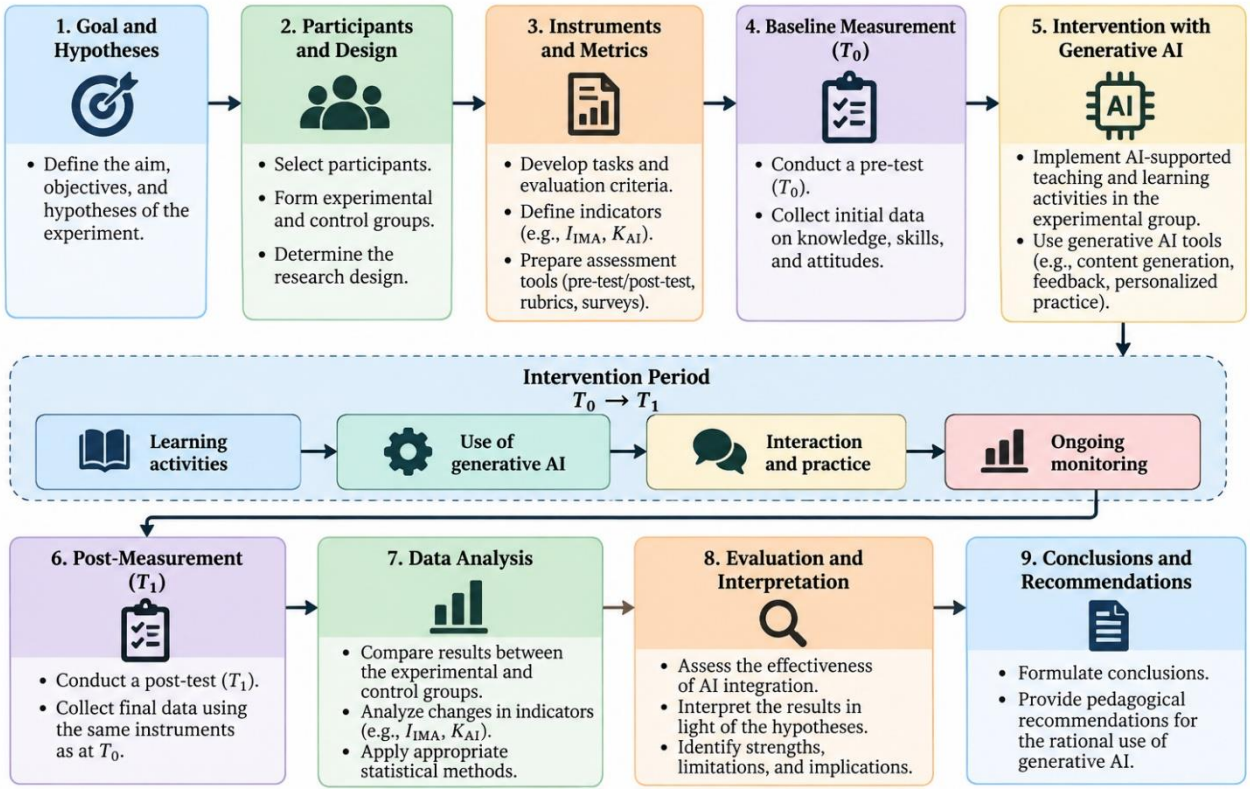
T_1 - final diagnostic assessment.

Table 3. Experimental Structure

№	Stage	Control group	Experimental group
1	**Baseline assessment**	**+**	**+**
2	**Conventional instruction**	**+**	**-**
3	**AI-critical-thinking model**	**-**	**+**

4	**Verification tasks**	**-**	**+**
5	**Academic reflection**	**Partial**	**Systematic**
6	**Final assessment**	**+**	**+**
7			

Figure 4. Algorithm of the Pedagogical Experiment Based on Generative Artificial Intelligence.



11. ASSESSMENT OF EXPERIMENTAL EFFECTIVENESS

The change in the experimental group is calculated as:

$$\Delta I_E = I_{E,1} - I_{E,0}$$

The corresponding change in the control group is:

$$\Delta I_N = I_{N,1} - I_{N,0}$$

The pedagogical effect is then:

$$E_p = \Delta I_E - \Delta I_N$$

If:

$$E_p > 0$$

and the difference is statistically significant, the findings may support the effectiveness of the proposed pedagogical intervention.

A positive $\mathbf{E_p}$ alone should not be regarded as sufficient proof without statistical testing.

12. STATISTICAL ANALYSIS

Depending on the experimental design, the results may be analyzed using:

- arithmetic mean and standard deviation;

- Student’s \(t\)-test where assumptions are satisfied;
- Mann-Whitney \(U\)-test for suitable non-parametric comparisons;
- effect-size measures such as Cohen’s \(d\).

The arithmetic mean is:

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

The sample standard deviation is:

$$s = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$$

The effect size may be estimated using Cohen’s \(d\):

$$d = \frac{\bar{x}_E - \bar{x}_N}{s_p}$$

where:

x_E - mean score of the experimental group;

x_N - mean score of the control group;

s_p - pooled standard deviation.

13. AI-BASED TASKS FOR DEVELOPING INDEPENDENT THINKING

Conventional assignments such as **“Write an essay on the topic”** may lose part of their diagnostic value when a generative AI system can produce a complete answer within seconds.

Therefore, the following types of assignments are proposed.

“Find the AI Error”

The learner asks AI a complex question and must identify factual, logical, or methodological weaknesses in the generated answer.

“Two AI Responses - One Human Decision”

The same problem is submitted to two AI systems or generated in two independent sessions:

$$AI_1 \leftrightarrow AI_2$$

The learner compares the responses and formulates:

$$D_{\text{human}}$$

where D_{human} is the student’s own final judgment.

“No Claim Without Evidence”

Every significant AI-generated claim must be supported or rejected using reliable academic sources.

“Debate with AI”

The student asks AI to produce arguments against the student’s own initial position and then re-evaluates that position.

“Final Answer Without AI”

AI may be used during exploratory and analytical stages, but the final conclusion is written independently after the AI interaction has ended.

Such assignments shift the pedagogical focus from **answer production** to **thinking quality**.

14. SCIENTIFIC NOVELTY OF THE PROPOSED APPROACH

The scientific novelty of the study may be expressed through several interrelated propositions.

First, generative AI use is conceptualized not merely as a digital skill but as a pedagogical process for simultaneously developing **independent thinking and academic responsibility**.

Second, the following human-centered pedagogical model is proposed:

$$\boxed{H_1 \rightarrow AI \rightarrow H_2}$$

Third, a compulsory verification stage is introduced between receiving an AI-generated response and accepting a conclusion.

Fourth, an integrative index:

$$\boxed{I_{\text{IMA}}}$$

is proposed for the comprehensive assessment of independent thinking and academic responsibility.

Fifth, the diagnostic indicator:

$$\boxed{K_{AI}}$$

is introduced to conceptualize the degree of cognitive reliance on AI.

Sixth, an iterative pedagogical cycle consisting of:

question - AI response - verification - critical analysis - alternative reasoning - human decision - reflection

is developed.

These propositions should be treated as the author’s proposed conceptual and methodological framework and subsequently subjected to empirical validation.

15. PRACTICAL SIGNIFICANCE

The proposed model can be applied in:

higher education institutions, teacher education programs, master’s programs, research methodology courses, independent learning, coursework and graduation projects, and digital pedagogy courses.

One important advantage of the model is that it is not tied to a specific generative AI platform.

Therefore, its pedagogical logic can remain relevant even as particular AI systems and interfaces change.

The model can also support universities in developing institutional recommendations concerning responsible student use of generative AI.

16. DISCUSSION

Recent research indicates that the educational effectiveness of generative AI depends less on the mere availability of the technology and more on the pedagogical design within which it is used.

A 2025 meta-analysis incorporating 57 studies and 97 effect estimates reported that generative AI may positively affect university students’ overall learning outcomes and higher-order thinking skills, although effects on metacognitive outcomes were less conclusive [7].

This observation is consistent with the central premise of the present model: interaction with AI alone does not automatically produce independent or reflective thinking.

Specially designed pedagogical mechanisms are required.

Systematic reviews of generative AI in higher education also emphasize the importance of learning-task design, clear educational goals, active student participation, academic integrity, and human supervision [5,6,10,11].

Accordingly, the pedagogical objective should not be to remove AI completely from higher education or to allow unrestricted automation of students’ cognitive work.

A more sustainable alternative is to transform AI use into a structured learning process in which the student must **question, verify, compare, criticize, decide, and reflect**.

In this context, the teacher’s role also changes.

The teacher increasingly becomes the designer of intellectual tasks, evaluator of reasoning quality, organizer of verification practices, and facilitator of responsible human-AI interaction.

CONCLUSION.

The integration of generative artificial intelligence into higher education does not automatically weaken or strengthen students’ independent thinking.

The educational outcome depends largely on the pedagogical model within which the technology is used.

This study proposes an integrative **“Human - AI - Human”** pedagogical model based on the principle that artificial intelligence should function as a supporting intellectual tool rather than as the final decision-making authority.

The model includes the stages of independent problem understanding, formulation of an initial hypothesis, AI interaction, information verification, critical analysis, independent decision-making, academic responsibility, and reflection.

An integrative framework consisting of cognitive, analytical-critical, verification, academic-responsibility, and reflective competencies is proposed for assessing student development.

A composite competency index is introduced together with a conceptual coefficient describing cognitive reliance on AI.

The proposed approach offers a pedagogical alternative to both complete prohibition and unrestricted use of generative AI.

Its central objective is to preserve and develop **human intellectual autonomy, academic responsibility, critical judgment, and reflective thinking while making constructive use of artificial intelligence technologies**.

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