

**PEDAGOGICAL METHODOLOGY FOR EVALUATING STUDENT
RESPONSES USING ARTIFICIAL INTELLIGENCE BASED ON
SEMANTIC ANALYSIS IN AN ELECTRONIC LEARNING
ENVIRONMENT**

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Annotation: In this article, the pedagogical methodology of evaluating students' textual responses using artificial intelligence based on semantic analysis in an electronic learning environment is analyzed. During the research, the didactic possibilities of natural language processing (NLP), Word2Vec, and BERT models, as well as the mechanisms of their integration into the educational process, are highlighted. The pedagogical advantages of semantically analyzing responses entered by students, determining their semantic proximity, and automatic evaluation are substantiated. Also, the role of artificial intelligence-based diagnostic systems in reflexive monitoring, individual feedback, and the development of intellectual competence is shown.

Keywords: Electronic learning environment, artificial intelligence, semantic analysis, NLP, Word2Vec, BERT, automatic evaluation, intellectual competence, reflexive monitoring, pedagogical methodology, learning analytics, digital pedagogy.

In the conditions of digital transformation, electronic learning platforms are becoming an important component of the modern pedagogical system. Especially, the issue of automating the process of evaluating students' knowledge and organizing individual monitoring is gaining urgent importance. Traditional test systems often work only on the basis of ready-option questions and cannot fully evaluate the student's independent thinking and semantic approach.

For this reason, technologies for evaluating open textual responses using artificial intelligence based on semantic analysis are becoming a pedagogically important direction. This approach allows for determining not only the student's correct answer but also their logic of thinking, level of understanding of concepts, and to what extent they have expressed semantic connections.

The purpose of this article consists of developing a pedagogical methodology for evaluating student responses using artificial intelligence based on semantic analysis in an electronic learning environment and substantiating its didactic possibilities.

Semantic analysis is the process of identifying the words, sentences, and their mutual semantic connections within a text. From a pedagogical point of view, this technology allows for determining the student's:

- level of understanding concepts;
- logical thinking;
- analytical approach;
- independent explanation;
- creative expression

allows for evaluating skills such as.

While traditional test systems only identify ready-made answers, artificial intelligence systems based on semantic analysis analyze the content of the answer. For this reason, this approach is considered close to the competency-based assessment methodology.

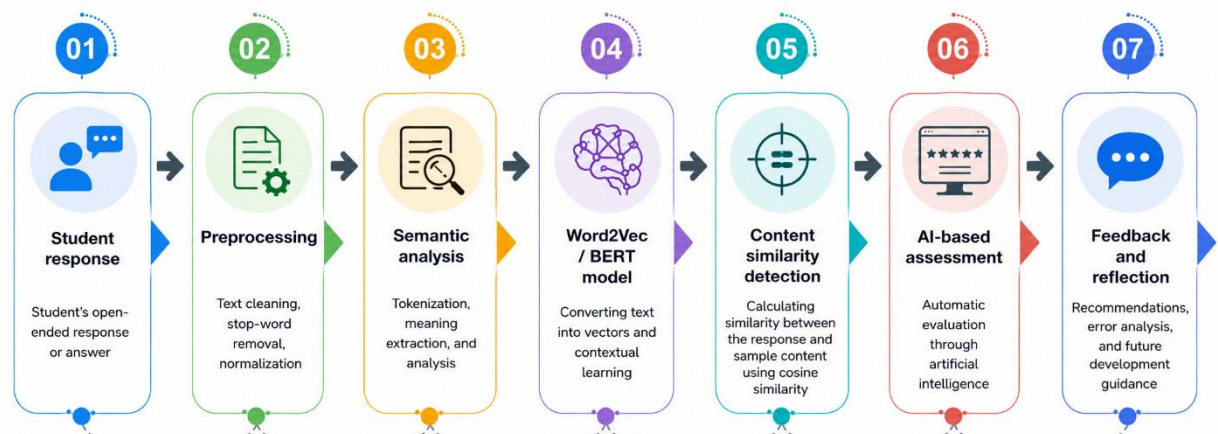


Figure 1. Pedagogical assessment model based on semantic analysis

Methodology for processing student responses

The assessment of textual responses entered into the electronic learning platform is carried out in several methodological stages.

1. Preprocessing stage – Initially, the text is cleaned from special characters, extra elements, and stop-words. This stage serves to increase the semantic accuracy of the system.

2. Tokenization and normalization – Student response is divided into separate tokens and words are brought to their lexical form. This allows for the analysis of words with the same meaning in different forms as a single semantic unit.

3. Vector modeling – The text is converted into digital vectors. In this process, Word2Vec or BERT models are used.

Word2Vec model - works fast, requires few resources, detects simple semantic connections.

The BERT model, on the other hand, performs contextual analysis, detects complex syntactic connections, and understands hidden semantic meanings.

Table 1

Pedagogical comparative analysis of Word2Vec and BERT models

Model	Pedagogical opportunity	Advantage
Word2Vec	Identifying key concepts, Assessment of simple responses	Works fast, Requires few resources
BERT	Contextual and deep analysis, Analyzing complex thoughts	High semantic accuracy, Possibility of reflexive assessment

The main pedagogical advantages of semantic assessment using artificial intelligence are as follows:

- individual approach;
- rapid diagnostics;
- reflexive monitoring;
- feedback mechanism;
- competency-based assessment;
- monitoring intellectual development.

This system semantically compares the student's answer with a model answer and evaluates it based on content similarity.

The Cosine Similarity algorithm is used to determine semantic similarity. Once the vectors are generated, their proximity to each other is calculated through the Cosine Similarity algorithm. This methodology determines how similar the content of two texts is, providing a value ranging from 0 to 1:

$$\cos(\theta) = \frac{A \cdot B}{\|A\| \cdot \|B\|}$$

Where:

A and B – Two vectors (for example, two texts or documents)

A · B – The dot product of the vectors

||A|| and ||B|| – The magnitude (length) of the vectors

θ (theta) – The angle between the two vectors

Reflexive monitoring and feedback

The AI system in the e-learning platform is not limited to just grading. It identifies mistakes, provides recommendations, suggests resources for relearning, and organizes reflective analysis.

As a result, the student gains the opportunity to independently monitor their level of knowledge, mistakes, and development dynamics.

This contributes to the development of the reflective component of intellectual competence.

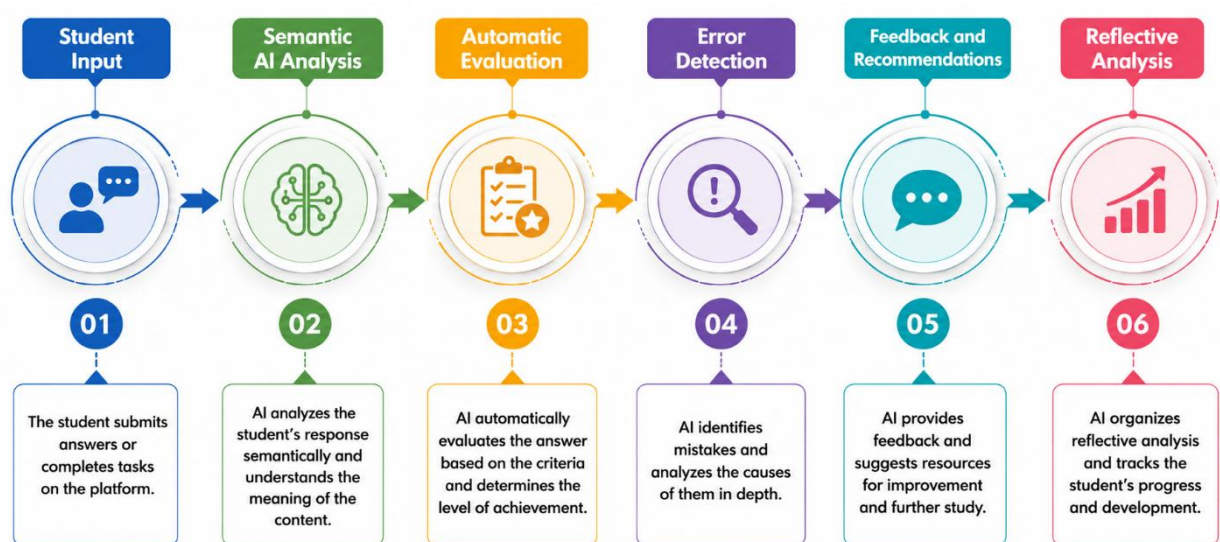


Figure 2. AI-Based Reflective Monitoring System

The research results showed that artificial intelligence systems based on semantic analysis enable:

- evaluation of open-ended responses;
- identification of the student's level of thinking;
- provision of individual feedback;
- organization of reflective monitoring.

In particular, it was found that the contextual analysis capability of the BERT model produces significantly more accurate results compared to traditional algorithms when evaluating complex responses.

In conclusion, evaluating students' responses in electronic learning platforms using artificial intelligence based on semantic analysis is considered one of the innovative directions of modern pedagogy.

This methodology makes it possible to ensure competency-based assessment, an individual approach, reflective monitoring, and rapid feedback.

While the Word2Vec model is convenient for rapid semantic analysis, it was found that the BERT model is more effective for complex contextual analysis and deep pedagogical diagnostics.

As a result, semantic AI systems emerge as an innovative pedagogical mechanism that serves to develop students' intellectual competence in the electronic learning environment.

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