CRITERION-BASED ASSESSMENT OF CHEMICAL CONCEPT MAPS USING ARTIFICIAL INTELLIGENCE

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This article proposes an artificial intelligence–based criterion-driven model for assessing chemical concept maps in chemistry education. The model is designed to evaluate not only the number of links between concepts, but also their scientific validity, logical coherence, hierarchical organization, and semantic depth. By focusing on the quality of conceptual connections, the proposed approach enables a more objective measurement of students' conceptual understanding. The model aims to standardize assessment practices, support meaningful formative feedback, and provide teachers with analytical insights into students' conceptual structures in chemistry. In chemistry education, meaningful learning depends on students' ability to construct coherent relationships among concepts rather than memorizing isolated facts. Concept maps are widely used to visualize such relationships; however, their assessment often remains subjective and inconsistent, relying heavily on individual teacher judgment. Measuring the depth and correctness of conceptual links poses a particular challenge. The integration of artificial intelligence into criterion-based assessment offers a timely solution by enhancing reliability, transparency, and scalability in evaluating chemical concept maps. This approach aligns with current demands for data-informed, formative, and learner-centered assessment practices in science education [1].

The purpose of this study is to develop and substantiate an artificial intelligence–supported, criterion-based model for assessing chemical concept maps that enables objective evaluation of the depth, structure, and scientific validity of conceptual relationships. The model is intended to provide a coherent framework for generating meaningful and interpretable feedback for both teachers and students in chemistry education. The proposed assessment model offers practical benefits by standardizing the evaluation of chemical concept maps through a transparent rubric, enhancing the quality and efficiency of formative assessment, and supporting diagnostic feedback on students' conceptual understanding. Its integration into digital learning environments allows continuous monitoring of conceptual development, thereby facilitating informed instructional decisions and differentiated teaching practices. The novelty of this research lies in shifting the assessment of chemical concept maps from simple quantitative indicators to a multidimensional semantic–criterion-based framework. The model introduces standardized indicators for evaluating conceptual depth, including scientific correctness, logical justification, and the explanatory power of relationships. It also operationalizes the notion of "deep connections" in chemistry—such as causal, mechanistic, and conditional relationships—and integrates them into a scalable assessment structure. This approach enables meaningful comparison across learners and learning stages while preserving pedagogical interpretability [2].

The artificial intelligence–based criterion assessment model proposed in this study provides a structured and objective approach to evaluating chemical concept maps. Its application supports deeper conceptual understanding by highlighting the quality of relationships among chemical concepts and identifying misconceptions at an early stage. The model enhances formative assessment by delivering actionable feedback and offers teachers a practical tool for guiding differentiated instruction. Overall, the approach contributes to improving the reliability of assessment and fostering conceptual coherence in chemistry education.

References

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