

*cognitive motivation in students. However, the authors emphasize the necessity for further empirical research, particularly regarding the alignment of interdisciplinary differentiation of academic disciplines and their integration in the context of ensuring stable cognitive motivation among students.*

**Key words:** *interdisciplinary connections, cognitive motivation, structuring of educational content, cognitive load, linear algebra, analytic geometry, chemistry-related problems.*

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## **PRINCIPLES OF UNIVERSAL DESIGN IN CHEMISTRY EDUCATION**

*The article is devoted to the theoretical justification and specification of methodological approaches to the implementation of the principles of Universal Design for Learning (UDL) in the process of teaching chemistry in general secondary education institutions. The relevance of the study is determined by the insufficient development of subject-oriented methodological solutions that integrate UDL principles with the specific features of chemistry as a school subject. The purpose of the article is to identify and describe pedagogical strategies for the organization of learning activities that ensure the implementation of the three core principles of UDL (providing multiple means of engagement, providing multiple means of representation, and providing multiple means of action and expression), taking into account the abstract nature of chemical concepts, the experimental nature of the subject, the multimodality of educational information, and safety requirements. A system of methodological strategies is proposed, which includes: organizing the study of chemistry content through diverse everyday and practical contexts with opportunities for choice and differentiation of roles within research groups; multisensory representation of chemical concepts through the integration of verbal explanations, symbolic notation, physical and virtual models, dynamic visualizations, and tactile tools; systematic use of augmentative and alternative communication (AAC) to support understanding of chemical terminology, processes, and laboratory actions; and providing students with alternative formats for demonstrating learning outcomes while maintaining unified assessment criteria for chemical content. The results obtained indicate that Universal Design for Learning in chemistry teaching methodology functions as a coherent system of practical pedagogical solutions aligned with the objectives of the New Ukrainian School reform.*

**Keywords:** *Universal Design for Learning, chemistry teaching methodology, multiple means of engagement, multiple means of representation, multiple means of action and expression, augmentative and alternative communication, multisensory approaches, multimodality, accessibility of the educational environment, variability of learning.*

**Problem Statement.** The reform of the national education system of Ukraine, initiated by the Law of Ukraine “On Education” (2017) and the implementation of the Concept of the New Ukrainian School, sets qualitatively new tasks for pedagogical science and educational practice. Among these tasks, one of the most significant is the creation of an educational environment capable of ensuring equal access to high-quality education for every child, regardless of their individual characteristics, abilities, and educational needs. Within international educational

discourse, the concept of Universal Design for Learning (UDL) has been actively developed. This concept proposes a systemic approach to designing the educational process – not as the adaptation of an existing system to the needs of particular students, but as the creation of a flexible and variable learning environment that takes natural human diversity into account at the stage of planning and organizing educational activities. In doing so, it ensures that every learner has the opportunity to choose the most effective pathway for achieving established educational goals.

However, an analysis of the current state of Ukrainian pedagogical research reveals a significant gap in the study of issues related to the application of Universal Design principles specifically within the methodology of teaching natural sciences, and chemistry in particular. Chemistry is characterized by a number of specific features that render the problem of accessibility and variability of instruction particularly relevant and methodologically complex. While general principles of inclusive education and the creation of accessible informational environments are represented in the works of Ukrainian scholars, concrete methodological developments concerning the organization of chemistry instruction on the basis of Universal Design remain practically absent in scientific publications. This includes, in particular:

- strategies for the formation of abstract chemical concepts taking into account different cognitive capabilities of students;
- approaches to organizing experimental work that would ensure the possibility of participation for students with diverse physical abilities;
- methods of varying the forms of presenting educational information and demonstrating learning achievements.

This gap has become especially evident in the context of the international Erasmus+ project “Comprehensive Introduction of Augmented and Alternative Communication Methodology into the Ukrainian System of Education” (AMUSE, 2025–2027). The purpose of this project is to modernize training programs for pedagogical staff through the development of courses on the methodology of using Augmentative and Alternative Communication (AAC) across various subject domains, including the natural sciences. Work carried out within this framework has revealed a critical need for a scientific substantiation of methodological approaches that would organically integrate the general didactic principles of Universal Design for Learning with the subject-specific characteristics of chemistry. Such integration must take into account both the psychological and pedagogical regularities of mastering chemical concepts and the didactic possibilities of modern technologies.

The specificity of chemistry as a school subject is determined by several interrelated factors that create both challenges and unique opportunities for the implementation of Universal Design principles. First, chemistry operates with highly abstract concepts (atom, molecule, chemical bond, electronic structure of matter, reaction mechanism) that are not directly accessible to sensory perception and require the formation of complex mental models. This presupposes a high level of development of abstract thinking and spatial imagination. Second, chemical education has a distinctly experimental character: the conduct of laboratory and investigative work constitutes an integral component of the educational process. This requires direct interaction with reagents and equipment, the possession of specific practical skills, and strict adherence to safety regulations. Third, instructional material in chemistry is inherently multimodal: the same phenomenon can and should be represented simultaneously at the macroscopic, microscopic, and symbolic levels. Full understanding presupposes not only the separate mastery of each level, but also the ability to establish connections between them and to move from one mode of representation to another.

It is precisely this multiplicity of forms of representation – often perceived in traditional practice as an additional complication – that, under methodologically sound organization, can become a powerful resource for implementing the principle of multiple means of representation. The multimodal nature of chemistry provides natural opportunities for students with different cognitive and sensory abilities to identify those forms of information presentation that are most accessible to them.

**Analysis of current research.** The conceptual foundations of Universal Design were formulated in the 1970s by American architect Ronald L. Mace, who proposed the idea of “design for all” to create environments accessible to the widest range of users without subsequent adaptation. In

1997, R. Mace and colleagues from the Center for Universal Design formulated seven fundamental principles [9], encompassing equitable and flexible use, intuitive clarity, perceptible information, tolerance for error, minimization of physical effort, and appropriate spatial configuration.

The adaptation of Universal Design to education is associated with the Center for Applied Special Technology (CAST, USA), where the concept of Universal Design for Learning (UDL) was developed in the 1990s. The starting premise was the recognition that learning difficulties are often determined not by individual characteristics of students, but by the organization of the educational process, oriented toward a hypothetical “average” learner. The theoretical foundation of UDL is grounded in neuroscientific research that identified three functional brain networks involved in learning: the affective, recognition, and strategic networks [14]. Differences in these networks account for the natural variability in learning, necessitating an educational environment that offers multiple pathways for achieving outcomes.

On these premises, CAST developed the UDL framework, which includes three interconnected principles: providing multiple means of engagement, multiple means of representation of instructional information, and multiple means of action and expression [16]. Each principle is further elaborated through guidelines and checkpoints, ensuring their practical application in the planning and implementation of the educational process.

In the international pedagogical literature, the application of UDL has been studied for more than two decades, with a discernible shift from conceptual substantiation to empirical investigations. In particular, research by L. Florian and H. Linklater [10] demonstrated that a key factor of professional competence is the teacher’s ability to organize instruction flexibly, focusing on students’ strengths rather than limitations. Teachers prepared on UDL principles exhibit greater confidence in working with diverse classrooms and less frequently resort to exclusionary practices.

A significant contribution to practical tools for UDL was made by the Department of Education of New South Wales (Australia), which proposed a structured framework for planning instruction [15]. The document contains algorithms for identifying learning barriers, examples of UDL implementation across various subject areas, including natural sciences, and instruments for evaluating effectiveness. Empirical data indicate that proactive planning taking learner variability into account improves the quality of the educational experience for all students.

A systematic review conducted by A. Al-Azawei, F. Serenelli, and K. Lundqvist [8] confirmed a consistent positive impact of this approach on academic achievement, motivation, and engagement. Particularly pronounced results were recorded in science and technical disciplines, where multimodal presentation of abstract information contributes to deeper conceptual understanding. Special emphasis is placed on the effectiveness of UDL in online and blended learning environments, which expand opportunities for varying the pace, forms of presenting material, and methods of demonstrating outcomes.

Within the context of science education, the work of the InterAcademy Partnership (IAP), which consistently supports inquiry-based science education (IBSE), is of considerable interest. Despite their different origins, IBSE and UDL share common methodological foundations, in particular an orientation toward the variability of cognitive pathways and the active role of the learner, which creates a basis for their integration in order to foster key twenty-first-century competencies.

In the Ukrainian educational context, the development of Universal Design ideas intensified after the ratification of the United Nations Convention on the Rights of Persons with Disabilities. In the works of L. Baida [2], I. Bihus [3], and A. Teitiak [5], Universal Design is considered as an intersectoral approach that has not only social but also economic justification. Subsequent studies emphasize the comprehensive nature of Universal Design in education, which encompasses the accessibility of the educational environment, curricula, information resources, and the professional development of teachers.

A number of instructional materials and practical recommendations, in particular the works of Ye. Honcharova [4] and I. Shepeniuk [7], propose tools for implementing UDL in professional practice, emphasizing the necessity of proactively embedding variability into the lesson structure. At the same time, critical analysis indicates the absence of specialized studies devoted to the methodological aspects of implementing UDL principles in the teaching of specific science

disciplines, particularly chemistry. Issues related to the organization of research activities, the formation of abstract chemical concepts, and the variation of ways in which learning outcomes are demonstrated remain insufficiently explored, which determines the relevance of this study.

**The purpose of this article** is to provide a theoretical substantiation and specification of methodological approaches to the implementation of the principles of Universal Design for Learning in the process of teaching chemistry in general secondary education institutions, taking into account the specific features of the subject, and to identify pedagogical strategies that ensure multiple means of engagement, representation of educational information, and demonstration of students' learning outcomes.

**Presentation of the main material.**

*Providing multiple means of engagement is the first principle of Universal Design for Learning* and is based on the recognition of the fundamental fact that learners differ significantly in what motivates and engages them in educational activity: what is interesting and meaningful for one student may prove completely uninteresting, detached from real life, or overly abstract for another. These differences are determined not only by individual traits of character or temperament, but also by prior life experience, cultural context, family values, professional orientations, personal interests, and hobbies. In the context of teaching chemistry – a subject traditionally perceived by many students as difficult, abstract, and disconnected from everyday life – the issue of motivation and engagement becomes particularly acute. If a student does not perceive personal meaning in studying chemical formulas, reaction equations, laws, and theories, and if all of this remains merely a set of symbols and rules to be memorized mechanically for the purpose of passing a test, then even the most refined teaching methods will not lead to genuine, deep understanding of chemical regularities, nor will they foster sustained interest in the subject that could serve as a foundation for further study of chemistry or for choosing a profession related to the natural sciences.

The application of the principle of multiple means of engagement in the methodology of teaching chemistry involves creating diverse “entry points” into chemical knowledge – varied contexts through which students can explore the same chemical concepts and regularities, while selecting those that are personally meaningful and relevant to them. For example, the topic “Main Classes of Inorganic Compounds” may be approached through several instructionally equivalent contexts that collectively encompass acids, bases, oxides, and salts. In the sphere of everyday life and nutrition, students may investigate the properties of acidic and alkaline substances in food products, processes of preservation, and the role of salts in flavor formation. Within household chemistry, attention may be directed to the composition and mechanisms of action of cleaning agents, the interaction of oxides with water, and the practical implications of acid–base reactions. An ecological perspective enables the study of acid rain, soil and water acidification, and the role of mineral salts in environmental systems. In the context of health and medicine, learners may analyze the regulation of acid–base balance in the human body and the chemical nature of pharmaceutical compounds. Finally, an industrial and technological context allows consideration of the production and application of inorganic compounds in metallurgy, construction materials, fertilizer manufacturing, and other sectors. Despite the diversity of these contexts, they lead students to the same system of fundamental chemical concepts and patterns, differing only in the situational framework through which these concepts are actualized.

It is important to emphasize that these contexts do not represent different topics or separate sections of the curriculum; rather, they are different pathways into the same chemical concepts (acid, base, salt, pH, indicator, neutralization), the same regularities (changes in substance properties depending on the pH of the medium; interactions between acids and bases), and the same experimental skills (determination of pH using indicators, titration). The difference lies solely in the specific objects and phenomena through which these concepts, regularities, and skills are formed. From an organizational perspective, this approach may be implemented through the creation of thematic research groups within the classroom. At the beginning of studying a topic, students are invited to choose one of the proposed contexts in accordance with their interests (those interested in cooking select the nutrition context; those concerned about environmental issues select the ecological context; those considering future careers choose the professional context,

etc.). Based on these choices, groups of students with similar interests are formed, each receiving a set of research objects corresponding to the selected context (for example, the “Nutrition” group receives various food products to measure their pH; the “Household” group receives different detergents; the “Ecology” group receives water samples from various sources, etc.). Within each group, students may further differentiate their roles according to their individual strengths and preferences: one student assumes the role of experimenter, working with reagents and equipment; another acts as an observer-documentarian, carefully recording the procedures and results in a form convenient for them (written notes, schematic drawings, photographs); another functions as a data analyst, systematizing results, constructing tables and graphs, and identifying patterns; another takes on the role of theorist, consulting textbooks, reference materials, and online resources to explain observed phenomena in terms of chemical theory; finally, someone may serve as presenter, responsible for preparing and delivering the group’s findings to the class.

Such an organization of work ensures the implementation of the engagement principle at several levels simultaneously: at the level of contextual choice (the opportunity to select what is personally interesting), at the level of role selection within the group (the opportunity to contribute through one’s strongest competencies), and at the level of social interaction (the opportunity to collaborate with peers who share similar interests).

Another important aspect of implementing the principle of multiple means of engagement is the creation of opportunities for self-monitoring, self-regulation, and reflection on one’s own learning process, which contributes to the development of a responsible attitude toward learning. In chemistry education, this may be achieved through the systematic use of structured checklists for laboratory and research work. Such checklists enable students, without constant teacher reminders, to track the sequence of experimental procedures, monitor compliance with safety regulations, assess the quality of obtained results, and identify possible sources of error. The use of reflective observation journals, in which students record not only the experimental protocol and conclusions after each laboratory activity but also responses to reflective questions such as “What surprised me most during this activity?”, “What difficulties did I encounter and how did I overcome them?”, “What did I understand about chemical processes as a result of this experiment?”, “What questions remain?”, and “Where might I encounter similar processes in everyday life?”, also promotes the development of conscious engagement with learning and the ability to identify personal strengths as well as areas requiring further development.

*Providing multiple means of representation* is the second principle of Universal Design for Learning. It acquires particular significance in view of the specific nature of chemical concepts, which are inherently multilevel and multimodal [11]. In the methodology of teaching chemistry, three levels of representation of chemical knowledge are traditionally distinguished [13]:

- the macroscopic level (what can be directly observed): changes in the color of solutions, formation of a precipitate or gas, release or absorption of heat, changes in the physical state of a substance, etc.;
- the submicroscopic or molecular level (what occurs at the level of atoms and molecules): breaking and formation of chemical bonds, electron transfer, changes in molecular spatial structure, interactions between particles at the molecular level – phenomena that cannot be directly observed but that constitute the underlying causes of macroscopic changes;
- the symbolic level (ways of representing chemical objects and processes through a specialized sign system): chemical formulas, structural formulas, reaction equations, graphs of dependencies, reaction mechanism schemes, and so forth.

From a pedagogical perspective, the most significant objective is not merely the separate mastery of each of these levels, but the formation of students’ ability to establish connections among them – to “translate” information from one form of representation into another. For example, when observing a macroscopic phenomenon (such as gas evolution upon adding acid to chalk), students should be able to explain it at the molecular level (the destruction of the calcium carbonate crystal lattice, interaction of carbonate ions with hydrogen ions, formation of unstable carbonic acid, which decomposes into water and carbon dioxide) and express it symbolically (the

chemical equation:  $\text{CaCO}_3 + 2\text{HCl} \rightarrow \text{CaCO}_3 + \text{H}_2\text{O} + \text{CO}_2\uparrow$ ). Conversely, when presented with a chemical equation, students should be able to predict the macroscopic indicators accompanying the reaction and conceptualize the corresponding changes occurring with atoms and molecules.

The structuring of such transitions between levels may be effectively supported through the use of algorithmic flowcharts that visually organize sequences of reasoning and problem-solving steps. Empirical research conducted in Ukrainian upper secondary schools has demonstrated that systematic work with algorithmic block-schemes significantly improves students' learning outcomes, particularly among those with initially lower levels of academic achievement [6].

This multilevel and multimodal character of chemical information, which in traditional teaching practice is often perceived as an additional complication that creates difficulties for students, can and should instead be regarded as a natural resource for implementing the principle of multiple means of representation. The very structure of the discipline provides an embedded opportunity to present the same chemical concepts and regularities in different forms, through different modalities, and via different channels of information perception.

Within the framework of multiple means of representation, particular significance is attached to the use of multisensory approaches in organizing and conducting chemical experiments. Traditionally, experimentation is perceived primarily as a visual activity: students observe changes in solution color, precipitate formation, gas evolution, crystal growth, or combustion. However, many chemical processes are accompanied not only by visible changes but also by other sensory effects that can and should be deliberately employed as additional channels for obtaining information about chemical phenomena. This is especially important for students with visual impairments, yet it also enriches the learning experience of all students, since engaging multiple sensory channels simultaneously promotes stronger retention and deeper conceptual understanding. For example, thermal effects accompanying chemical reactions (exothermic and endothermic processes) may be perceived tactilely by carefully touching the outer wall of laboratory glassware – strictly in compliance with safety regulations and following prior instruction.

An important instrument for implementing the principle of multiple means of representation in chemistry education is the systematic and purposeful use of augmentative and alternative communication (AAC) tools. Although AAC is traditionally associated with supporting students with severe speech impairments or autism spectrum disorders, it may in fact benefit a much broader range of learners, including those for whom the language of instruction is not native, students who experience difficulties memorizing verbal information, those who perceive visual information more effectively than verbal explanations, as well as all learners at the initial stages of studying new material, when terminology has not yet been internalized and graphic symbols can serve as cognitive scaffolds. In the context of chemistry teaching, an AAC system may involve the development and consistent use of graphic symbols – simple, easily recognizable, intuitively understandable images – to denote key chemical concepts, processes, operations, and laboratory safety rules. For example, pictograms may be used to represent states of matter (a solid depicted as densely packed particle circles; a liquid as closely positioned but mobile circles; a gas as widely spaced circles); types of chemical reactions (a synthesis reaction shown as two separate parts joined by an arrow into a larger whole; a decomposition reaction as a single entity breaking into two or more parts; a single-displacement reaction as an exchange of elements between two molecules; a double-displacement reaction as a mutual exchange of parts); properties of substances (solubility represented as a substance dissolving in water; flammability as a flame; toxicity as a skull and crossbones); laboratory safety rules (mandatory use of safety goggles indicated by a figure wearing protective glasses; the requirement to work under a fume hood shown by its image; caution when handling corrosive substances represented by a hand with a droplet falling on it); and stages of experimental procedures (prepare equipment – laboratory glassware on a table; measure reagents – a graduated cylinder; mix – two liquids being combined; observe – an eye symbol; record results – a pencil and notebook).

*Providing multiple means of action and expression* is the third principle of Universal Design for Learning. It is based on the recognition of the fundamental fact that students differ not only in the ways they perceive and process information (which is the focus of the second principle), but also in the ways

they interact with learning material, complete educational tasks, and demonstrate what they have learned, what they have understood, which skills they have mastered, and which competencies they have developed [12]. Traditional assessment practice in chemistry, as in most other school subjects, is quite often limited to a relatively narrow, standardized set of formats: written tests that include algorithm-based problem solving and answers to theoretical questions from the textbook; standardized laboratory reports with a rigidly prescribed structure (topic, aim, equipment and reagents, step-by-step procedure, observations presented in a table, reaction equations, conclusions, answers to control questions), which are frequently assessed more for compliance with format than for understanding of substance; multiple-choice tests or matching tasks that primarily assess recognition and mechanical memorization rather than deep understanding. Although these traditional forms of assessment undoubtedly have their value, correspond to certain didactic objectives, and make it possible to verify specific aspects of students' learning outcomes, they may create significant, and sometimes insurmountable, barriers for those students who, for various reasons, experience difficulties precisely with these particular forms of demonstrating their knowledge.

The application of the principle of multiple means of action and expression in the methodology of teaching chemistry presupposes the creation and systematic, consistent provision to students of a wide range of diverse alternative ways and formats for demonstrating their knowledge, skills, understanding of chemical regularities, and formed competencies, while each of these ways should be assessed according to the same fair, transparent criteria related to depth of understanding, ability to apply knowledge, capacity to analyze and synthesize information, etc., rather than to the form of presentation or technical aspects of performance.

For example, instead of a single mandatory written report on an experimental investigation for all students, learners may be offered a choice among several equivalent alternatives:

- traditional written report with a description of the stages of work, tables of observations, chemical reaction equations, and well-reasoned conclusions (this format remains available and may be chosen by students who possess well-developed skills of structured written presentation of information);
- video recording of the process of conducting the experiment with oral commentary in real time, in which the student explains what is being done at each stage, justifies the sequence of actions, anticipates expected results, documents actual observations, and interprets the observed phenomena; the pedagogical effectiveness of such video-based laboratory reporting has been demonstrated in research on the organization of chemical experimentation under distance learning conditions in higher education, indicating its potential for adaptive use in general secondary education (this format is particularly suitable for students with well-developed oral communication skills and the ability for spontaneous speech and reflection directly in the course of activity) [1];
- multimedia presentation combining photographs of key stages of the experiment, schemes or diagrams illustrating the essence of chemical processes, graphs of dependencies, and brief textual comments for each slide (for students who are proficient in digital technologies and able to effectively integrate different types of information);
- infographic – a visually attractive poster that, through a system of pictograms, schemes, diagrams, and arrows, presents the essence of the experiment, the sequence of actions, the main observations, the obtained results, and the formulated conclusions (for students with developed visual-spatial thinking);
- oral presentation directly before the class or individually before the teacher with simultaneous demonstration of key moments of the experiment (for students who better express their thoughts orally in a mode of direct dialogue);
- mind map or structural-logical scheme showing the system of connections between different chemical concepts involved in the experiment and the cause-and-effect relationships between various factors (for students inclined toward systematic, structured thinking).

At the same time, it is important to understand, consistently keep in mind, and clearly communicate to students that providing them with a choice of format for presenting results in no way

implies a reduction of academic requirements or a relaxation of assessment criteria. It means only that the same knowledge, the same deep understanding of chemical principles, and the same developed competencies may be adequately and fully expressed in different forms, through different modes, and via different communication channels, and that fair, objective assessment should focus on content and substance rather than on the form of presentation or technical aspects. Regardless of the format chosen by the student, he or she is expected to demonstrate the same learning outcomes established by the curriculum and standards: understanding the chemical nature of processes; the ability to explain observed phenomena; the capacity to correctly represent processes using chemical symbolism; the ability to analyze obtained results and compare them with theoretically expected ones; the capacity to formulate well-reasoned conclusions; and the ability to identify connections between the completed work and other studied topics, real-life contexts, and practical applications.

**Conclusions and prospects for further research.** The study asserts that the principles of Universal Design for Learning have significant potential for improving the process of teaching chemistry in general secondary education institutions. The three interrelated UDL principles – multiple means of engagement, representation, and action and expression – are organically aligned with the specific features of chemistry and the didactic regularities of forming chemical concepts. Applying UDL makes it possible to transform characteristics traditionally perceived as sources of difficulty (abstract concepts, the necessity of experimental methods, and multimodality of information) into powerful resources for creating a flexible and adaptive learning environment that supports the diverse needs of learners.

The specific methodological approaches proposed for implementing each UDL principle demonstrate that their realization in chemistry teaching is not an abstract idea, but a practical, methodologically substantiated system of concrete solutions that can be implemented by teachers in the real conditions of the New Ukrainian School.

Prospects for further research are seen in the development and empirical validation of methodological guidelines for chemistry teachers on applying UDL principles in various topics, as well as in studying the possibilities of using modern digital technologies and online tools for a more comprehensive implementation of universal design in chemistry education.

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**Бабенко О. М., Харченко Ю. В., Матерієнко А. С. Принципи універсального дизайну в навчанні хімії.**

Статтю присвячено теоретичному обґрунтуванню та конкретизації методичних підходів до реалізації принципів універсального дизайну навчання (УДН) у процесі навчання хімії в закладах загальної середньої освіти. Актуальність дослідження зумовлена недостатньою розробленістю предметно-орієнтованих методичних рішень, що поєднують принципи УДН зі специфікою хімії як навчального предмета. Метою статті є визначення та опис педагогічних стратегій організації навчальної діяльності, які забезпечують реалізацію трьох базових принципів УДН (надання різноманітних способів залучення, надання різноманітних способів представлення інформації та надання різноманітних способів дії й самовираження) з урахуванням абстрактного характеру хімічних понять, експериментальної природи предмета, мульти-

модальності навчальної інформації та вимог безпеки життєдіяльності. Запропоновано систему методичних стратегій, яка включає: організацію вивчення матеріалу навчального предмета хімії через різноманітні побутові та практичні контексти з можливістю вибору і диференціації ролей у дослідницьких групах; мультисенсорне представлення хімічних понять шляхом поєднання вербальних пояснень, символічних записів, фізичних і віртуальних моделей, динамічних візуалізацій та тактильних засобів; систематичне використання засобів альтернативної та додаткової комунікації для підтримки розуміння хімічної термінології, процесів і лабораторних дій; надання учням альтернативних форматів демонстрації результатів навчання за умови збереження єдиних критеріїв оцінювання хімічного змісту. Отримані результати засвідчують, що універсальний дизайн навчання у методиці навчання хімії виступає цілісною системою практичних педагогічних рішень, релевантних завданням Нової української школи.

**Ключові слова:** універсальний дизайн навчання, методика навчання хімії, множинні засоби залучення, множинні засоби представлення, множинні засоби дії та самовираження, альтернативна та додаткова комунікація, мультисенсорні підходи, поняття мультимодальності, доступність освітнього середовища, варіативність навчання.

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## МЕТОДИКА РЕАЛІЗАЦІЇ ШКІЛЬНОГО ФІЗИЧНОГО ЕКСПЕРИМЕНТУ З КІНЕМАТИКИ В ЗАКЛАДАХ ЗАГАЛЬНОЇ СЕРЕДНЬОЇ ОСВІТИ ЗА МОДЕЛЬНИМИ НАВЧАЛЬНИМИ ПРОГРАМАМИ В УМОВАХ ДИСТАНЦІЙНОГО НАВЧАННЯ

Метою статті є дослідження ефективних методів навчання розділу фізики «Кінематика» в сучасній шкільній освіті, з урахуванням інтеграції цифрових технологій і активних форм навчання для підвищення пізнавальної активності учнів та формування компетентностей предметної галузі. Предметом дослідження є педагогічні технології і методики викладання кінематики, направлені на розвиток предметних умінь та компетентностей школярів.

Методи дослідження включали теоретичний аналіз науково-методичної літератури, експериментальне впровадження цифрових інструментів у навчальний процес, а також емпіричні процедури, що передбачали спостереження, анкетування і статистичну обробку результатів навчальної діяльності здобувачів. Для забезпечення комунікації та дистанційного навчання були застосовані платформи Microsoft Teams, Zoom, Moodle.

Результати дослідження демонструють підвищення ефективності навчання кінематики завдяки використанню інтерактивних симуляцій і цифрових інструментів, що сприяють кращому розумінню фізичних явищ, розвитку вміння аналізувати експериментальні дані та формуванню навичок роботи з графіками і діаграмами. Запровадження активних методів навчання змінює ролі надавача освітніх послуг і здобувачів, посилюючи мотивацію і самостійність здобувачів у навчанні.

Практичне значення полягає у розробці методичних рекомендацій щодо інтеграції цифрових технологій у вивчення кінематики, що може бути використано при підготовці вчителів фізики, а також у безпосередньому освітньому процесі в закладах загальної середньої освіти. Запропоновані підходи сприяють підвищенню якості освіти та відповідають вимогам Нової української школи.