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METHOD OF DEVELOPING CHEMICAL LANGUAGE IN STUDENTS BASED ON DIGITAL STORYTELLING

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Abstract

This article examines a method for developing students' chemical language through digital storytelling. The proposed methodological solution involves a sequence of activities in which students not only create a digital story but also translate the content of a chemical phenomenon from its observed form into a verbal explanation, a microcosm model, and a symbolic notation. The method includes setting up a chemical situation, identifying the linguistic core of the topic, a sequential description of the process, peer review of the scenario, creation of a digital story, and reverse transformation of the information. To evaluate the results, criteria for terminological and symbolic accuracy, understanding of the meaning of chemical notation, logical explanation, and coherence of chemical language are identified. The proposed approach can be used in studying exchange reactions, electrolytic dissociation, oxidation-reduction, and organic reactions.

Keywords: chemical language, digital storytelling, chemical symbols, nomenclature, chemical formulas, reaction equations, chemistry teaching.

Introduction

Chemical language occupies a special place in the school chemistry curriculum, as it enables students to obtain, record, and convey information about substances and chemical transformations. When studying the subject, students must correctly use chemical terms, read and construct formulas, distinguish between indices and coefficients, use ionic charge symbols, construct reaction equations, and explain the meaning of their notations. Therefore, mastery of chemical language cannot be reduced to memorizing symbols alone. It is important for students to understand the meaning of a symbol or formula and be able to associate the notation with a specific substance, its structure, properties, and the process taking place (Pak M.S., 2023).

In modern methodology, chemical language is considered the most important teaching tool, including terminology, nomenclature, and

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chemical symbolism (Petukhov S. Yu., 2024). He emphasizes that the consistent acquisition of chemical language creates the basis for sustainable subject results, and that working with the symbolic system should include not only the correctness of notation, but also an understanding of its meaning and practical application (Makarova N. A., 2016). He also notes that operations with chemical symbols are associated with analysis, comparison, modeling, and other mental processes; therefore, chemical notation can act not only as a result of memorization, but also as a means of cognitive activity for the student.

At the same time, school education is increasingly using digital forms of information presentation, which can be traced in the works of methodologists (Alimova FA, 2026), (Akimkhodzhaeva G.I., 2026).One such form is digital storytelling – the creation of an educational story using text, images, diagrams, audio, video and other multimedia elements.

Literature review

In pedagogical literature, digital storytelling is considered an educational practice that enables project-based learning, makes educational information more visual, and engages students in the independent creation of meaningful digital products (Nazarova O.S., 2018), (Toktarova V.I., Semenova D.A., 2023). Research conducted with schoolchildren shows that an active format is particularly significant, where the student acts not only as a viewer of the finished story but also as its author (Poskakalova T.A., 2023).

International studies consider the development of chemical language as an important prerequisite for developing students' subject knowledge (Rees et al., 2018) examined the potential of language-focused tasks for understanding chemical terminology. (Ho et al., 2024) substantiated the pedagogical potential of contextual storytelling in the study of general chemistry. A study by Nugraha and Harsono (2024) examined the creation of digital stories using artificial intelligence, and (Fernández et al., 2023) examined the use of student-created videos to understand chemical reactions.

Multimedia alone is insufficient for teaching chemistry. A catchy video may attract attention, but it may also contain inaccurate terminology, an incorrectly constructed formula, or a formal reaction equation. Therefore, this paper examines digital storytelling not as a means of embellishing educational material, but as a form of organizing activities in which storytelling is subordinated to the development of chemical language. Students must select chemical concepts, explain the observed phenomenon, correctly represent it symbolically, and connect all elements into a coherent scientific text.

The aim of our study was to develop and theoretically substantiate a method for developing students' chemical language using digital storytelling. The object of the study was the process of teaching chemistry in a comprehensive school. The subject of the study was the content and methods of educational activities aimed at developing students' chemical terminology, nomenclature, symbolism, and coherent chemical language through the creation of digital stories. To achieve this goal, we analyzed scientific and methodological sources, identified the components of chemical language, developed a sequence of learning activities, and proposed criteria for evaluating the results.

Research methodology

The study was project-based and methodological in nature. It included an analysis of scientific and methodological literature, a comparison of approaches to developing chemical language, pedagogical modeling, the design of learning tasks, and the development of a criteria-based assessment system. The theoretical basis of the methodology was the concept of chemical language as a system of terminological, nomenclature, and symbolic teaching tools, as well as concepts of digital storytelling as a form of active learning and project-based activity. The study developed a methodological model, "digital chemical history." Its purpose is to challenge students to repeatedly transform the same chemical information: to observe a phenomenon, name its characteristics, explain what is happening, select the necessary terms, represent the process with formulas or equations, and then present everything in a logical digital story. This repeated transformation allows one to determine whether the student understands the chemical notation or is merely reproducing it from a template.

The first stage is setting up a chemical situation. The work begins with an experiment, a photograph, a short video clip, a drawing, or a problematic question. At this stage, students record only what can be directly observed. For example, when mixing solutions of copper (II) sulfate and sodium hydroxide, a blue precipitate is observed. The teacher deliberately separates observation and explanation to prevent students from substituting a memorized formulation for the actual reaction.

The second stage is identifying the linguistic core. Students determine which words, concepts, and chemical symbols are necessary to accurately describe the situation. In the example under consideration, the linguistic core includes the terms "solution," "ion," "precipitate," "exchange reaction," the name "copper (II) hydroxide," and the formulas $CuSO_4$, NaOH, $Cu(OH)_2$, and Na_2SO_4. This stage checks the correct reading of formulas, the use of nomenclature, indices, and ion charges.

The third stage is a sequential chemical description. First, the student formulates the observed result: when two solutions are mixed, a blue precipitate forms. Then, they explain this in terms of the composition of the solution particles: Cu^{2+} ions interact with OH^- ions to form sparingly soluble copper (II) hydroxide. Next, the molecular equation is formulated: $CuSO_4 + 2NaOH \rightarrow Cu(OH)_2\downarrow + Na_2SO_4$, and after studying ionic reactions, the abbreviated ionic equation is formed: $Cu^{2+} + 2OH^- \rightarrow Cu(OH)_2\downarrow$. A verbal or written explanation of the meaning of each transition is mandatory.

The fourth stage is mutual language checking. Before creating the final digital material, students exchange draft scripts and check them on the following questions: are the substances and processes named correctly; is the formula consistent with the name; are the indices, coefficients, and charges correctly placed; has the relationship between the observation and the chemical notation been explained; and are there any common expressions in the text that distort the scientific meaning. A student who discovers an error must not only point it out but also explain the reason for the correction. This activity turns the mutual checking into an exercise in chemical language.

The fifth stage involves creating a digital story approximately 2-4 minutes long. It includes the initial chemical situation, an image or video of the phenomenon, the necessary formulas and diagrams, and the student's voice or text explanation. The technical

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complexity of the editing is not the primary criterion. Priority is given to the accuracy of the chemical content, the logic of presentation, and the correct use of subject-specific language. This is consistent with the understanding of digital storytelling as a means of presenting educational content and organizing independent student activities.

The sixth stage is the reverse transformation. After viewing the completed digital story, the teacher asks the student to complete the task in a different format: reconstruct the equation from the verbal description; explain the chemical meaning of the completed formula; identify the substances and write the reaction using the particle diagram; correct the erroneous chemical entry. If the student succeeds without relying on the completed story, this indicates a more conscious use of chemical language.

Five criteria are proposed for evaluating results: 1) terminological accuracy - correct use of concepts and names of substances; 2) symbolic literacy - correctness of formulas, indices, coefficients, charges, and chemical symbols; 3) semantic accuracy - understanding the information conveyed by chemical notation; 4) logical explanation - the ability to establish a connection between the observed phenomenon, chemical composition, and reaction equation; 5) coherence of chemical speech - consistency and scientific correctness of oral or written statements. Each criterion can be assessed on a scale from 0 to 3 points, allowing one to see not only the overall result but also the specific area of difficulty the student is experiencing.

Analysis and results

The result of the project-based learning phase was a comprehensive model for the development of chemical language, integrating subject-based content and digital project-based activities. Its conceptual chain is structured as follows: "chemical phenomenon - precise verbal description - explanation - chemical symbolism - digital history - reverse transformation." The digital product is considered academically complete only when all elements are aligned.

The proposed sequence allows for simultaneous work with several components of chemical language. Using the example of the formation of $Cu(OH)_2$, the student uses nomenclature names of substances, reads and constructs formulas, applies coefficients, explains the sign of precipitation, uses ion symbols, and relates the abbreviated ionic equation to the observed experimental result. Peer-to-peer verification further develops the ability to recognize chemical errors and correct them with justified arguments. This approach is consistent with the need to move from the reproductive use of chemical symbols to their meaningful application in educational and cognitive activities.

This methodology can be used in various sections of the school curriculum. When studying electrolytic dissociation, the digital history is built from the properties of the solution and the composition of the electrolyte to the recording of ionic processes; when studying redox reactions, from the observed change to the determination of oxidation states and electron balance; in organic chemistry, from the property of a substance and the change in molecular structure to the recording of the corresponding transformation. When studying nomenclature, the digital history can be built around the sequential transition "composition of a substance - formula - compound class - name - properties."

Of particular importance is the fact that the digital story is created by the student themselves. Research on digital storytelling shows that the active format involves independent selection and structuring of content, script creation, visualization, and subsequent reflection. In the proposed method, these activities are directed toward a specific subject-specific outcome: competent proficiency in the language of chemistry.

The proposed approach differs from the typical use of digital storytelling in that the multimedia product is not viewed as an end in itself. The primary learning outcome is formed even before editing: the student selects concepts, verifies the names of substances, creates formulas and equations, correlates chemical notation with the observed process, and formulates a scientific explanation. Thus, digital storytelling becomes a form of organizing subject-based activities, and not just a means of emotional or visual presentation of material.

From a methodological perspective, this is important because, when developing chemical language, there is a risk of focusing on the external, formal aspects of symbolism. Makarova N.A. (2016) draws attention to the need to develop not only the grammatical correctness of chemical notation but also its semantic and functional aspects. Petukhov S.Yu. (2024) also views chemical language as a teaching tool that allows not only for the recording but also for the interpretation of chemical information. This is why the developed model includes a reverse transformation after the creation of a digital history, which tests independent understanding.

Conclusion

The use of digital storytelling is in line with the current trend of digitalization of education, but its effectiveness depends on the teaching scenario. For school-age students, the experience of actively creating digital stories, where students independently transform educational material and discuss the resulting product, is also significant. Applied to chemistry, this shifts the focus from viewing prepared multimedia materials to independently constructing a precise chemical message. Our proposed criteria-based assessment allows us to separately track the dynamics of terminological precision, symbolic literacy, understanding of chemical notation, and the coherence of subject-matter discourse.

Thus, digital storytelling can be used to develop chemical language, provided the central goal remains not the creation of a spectacular video, but the consistent transformation of chemical content from one form to another. The developed methodological model combines work with terminology, nomenclature, and symbolism with independent digital project-based activities by students. This creates the conditions for the transition from the mechanical reproduction of formulas and equations to their conscious use in explaining chemical phenomena.

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