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THE ROLE OF ACADEMIC LANGUAGE IN THE DEVELOPMENT OF SCIENTIFIC UNDERSTANDING

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Abstract

Misunderstandings of scientific concepts are commonly attributed to students' lack of knowledge or ineffective instructional practices. However, such an interpretation remains incomplete. A growing body of pedagogical and interdisciplinary research demonstrates that many learning difficulties in science arise not only from conceptual gaps but also from language-related challenges. Scientific knowledge is communicated through specialized terminology, complex syntactic structures, and abstract forms of representation, all of which may hinder comprehension, particularly for learners who are still developing proficiency in academic language.

This article argues that misunderstanding science is fundamentally both a cognitive and a linguistic phenomenon. Drawing on insights from cognitive psychology, second language acquisition, and content and language integrated learning, it examines how language shapes comprehension, contributes to the formation of misconceptions, and influences students' engagement with scientific knowledge. Particular attention is given to the role of terminology, the interference of everyday language, classroom discourse, and multilingual learning contexts. It is argued that effective science education requires the systematic integration of content

and language instruction in order to support meaningful and sustainable understanding.

Keywords: academic language, scientific understanding, conceptual change, multilingual education, classroom discourse, science education.

In the modern educational landscape, scientific understanding is considered a complex, multidimensional process that extends well beyond mere fact accumulation. It involves constructing holistic mental models, interpreting empirical data and applying abstract theoretical principles in a variety of contexts. From a cognitive psychological standpoint, the acquisition of scientific knowledge is inextricably linked to the process of conceptual change — the deep restructuring of students' existing ideas and knowledge. It is important to emphasise that this process is complicated by the fact that students are not 'clean slates'; they enter the educational environment with intuitive ideas already formed on the basis of everyday experience.

One of the key factors influencing the effectiveness of this process is the use of academic language as a specific tool for scientific communication. A major challenge to students learning science is the academic language in which science is written. Academic language is designed to be concise, precise, and authoritative. To achieve these goals, it uses sophisticated words and complex grammatical constructions that can disrupt reading comprehension and block learning. Students need help in learning academic vocabulary and how to process academic language if they are to become independent learners of science [1].

Thus, mastering academic language is a central problem in the development of scientific thinking. Without a proper grasp of its lexical and grammatical features, students will struggle to read, interpret and critically understand scientific texts. Therefore, effective teaching of the natural sciences should not only involve transferring substantive knowledge, but also purposefully forming the linguistic competencies necessary for working with scientific information.

It is important to note that students' intuitive ideas — the so-called naive or alternative concepts — are often extremely stable. These are not only rooted in

personal experience, but also in the linguistic structures through which this experience is made sense of. This is why academic language plays a dual role: it can complicate access to scientific knowledge, but it can also act as a powerful tool for deeper understanding and the reconstruction of cognitive models.

A crucial yet frequently underestimated factor in this process is language. Scientific concepts are not accessed directly but are mediated through linguistic representations. To understand a new idea, students must first comprehend the explanation through which it is conveyed. If the language used is ambiguous, unfamiliar, or cognitively demanding, the process of conceptual change may be significantly hindered. In this sense, language functions as a gatekeeper to scientific knowledge, shaping both access to and interpretation of meaning.

The distinctive nature of scientific language constitutes one of the primary sources of difficulty for learners. Academic language is substantially more formal, nuanced, and sophisticated than informal spoken language used outside of the classroom. Academic language takes centre stage in curriculum development and implementation. Academic language is the language required by students to appreciate and communicate in the academic setting; and it follows a set of principles that are precise, formal, and scientific, as well as objective and analytical in nature [2].

Scientific discourse is characterized by precision, abstraction, and a high degree of specialization. Unlike everyday language, which is often context-dependent and flexible in meaning, scientific language aims to eliminate ambiguity and ensure consistency. As a result, many common words acquire specific, restricted meanings in scientific contexts.

Terms such as “force,” “energy,” “power,” and “work” illustrate this phenomenon. While these words are widely used in everyday communication, their scientific meanings differ significantly from their colloquial interpretations. For instance, in everyday language, “work” typically refers to effort, labor, or activity. In physics, however, it is defined as the product of force and displacement in a given direction. When students encounter such terms, they often rely on their existing

linguistic knowledge, leading to misinterpretations that can obstruct understanding.

This conflict between everyday and scientific meanings highlights the importance of semantic accuracy in science education. Students must not only learn new concepts, but also reassign meanings to familiar words, rethinking them within scientific theories and models. This process requires not just rote memorization of terms but a profound cognitive restructuring that involves changes not only in vocabulary but also in the way they think. Without clear instructions that address these differences, students may unconsciously apply inappropriate interpretations, leading to the formation and consolidation of persistent misconceptions.

It is important to consider that these errors are often systemic, since the everyday meanings of words are embedded in students' experiences and supported by their linguistic environment. For example, when a scientific term has a different or narrower meaning than in everyday speech, students tend to interpret it through already familiar linguistic schemes. The result is semantic interference, which complicates the understanding of scientific explanations and prevents the formation of correct conceptual connections. That is why the learning process should include special strategies aimed at identifying, discussing and rethinking such discrepancies.

Effective processing of scientific vocabulary involves using various didactic techniques, such as contextualizing terms, comparing them with everyday meanings, and creating situations in which students can actively use new concepts in speech. It also involves encouraging students to explain and argue. This approach not only clarifies the meanings of words but also integrates them into a broader system of knowledge. In addition, work with the dictionary should be continuous and consistent, covering the introduction of new terms and their application in different contexts.

Therefore, studying scientific vocabulary is a central component of conceptual development, rather than a secondary activity. This is essential for transitioning from intuitive, everyday understanding to scientific thinking, ensuring accuracy, coherence and depth of knowledge acquisition.

The challenges associated with scientific language are further amplified in

multilingual educational contexts. Research in second language acquisition indicates that learners frequently transfer meanings, structures, and interpretive strategies from their first language into the target language. While such transfer can sometimes facilitate learning, it may also lead to interference, particularly when concepts do not align across languages. In science education, this can result in additional layers of misunderstanding, as students attempt to reconcile multiple linguistic systems with discipline-specific knowledge.

Moreover, scientific texts often employ complex grammatical features that increase cognitive demands. Passive constructions, nominalizations, and dense noun phrases are common in academic discourse, as they allow for concise and impersonal presentation of information. However, these structures can obscure meaning for learners who are not yet proficient in academic language. For example, a sentence such as “the acceleration of the object was measured” compresses information in a way that may be difficult to unpack, especially for novice readers.

The relationship between language and conceptual understanding becomes particularly evident in the process of conceptual change. Replacing incorrect or incomplete ideas with scientifically accurate ones requires more than exposure to correct explanations; it involves active engagement, critical reflection, and the ability to articulate reasoning. Language provides the essential tools for these cognitive processes. Through language, students can express hypotheses, compare alternative explanations, justify conclusions, and negotiate meaning with others [3].

In this regard, the ability to explain scientific concepts in one’s own words is a strong indicator of meaningful learning. Explanation requires the organization of knowledge, the selection of appropriate terminology, and the construction of coherent arguments. These processes are inherently linguistic and depend on the development of academic language proficiency. Without such proficiency, students may possess partial or implicit understanding but lack the means to fully develop or demonstrate it.

Pedagogical approaches that integrate language and content provide effective solutions to the challenges involved in acquiring scientific knowledge. Content and

Language Integrated Learning (CLIL), in particular, is based on the idea of simultaneously developing subject knowledge and language competence. Within this approach, language is not only viewed as a means of transmitting information but also as a tool for thinking and cognition. This contributes to a deeper understanding of the educational material. By incorporating linguistic support into subject teaching, CLIL highlights the interdependence of content and language, encouraging teachers to make the linguistic features of scientific discourse explicit to students and facilitating meaningful communication [4].

The implementation of such approaches involves introducing language-oriented educational practices, among which oral and written argumentation occupy a special place. Research shows that joint discourse in the classroom contributes to the development of conceptual understanding, especially when educational discussions are specifically organized for the reasoned exchange of ideas. At the same time, written tasks, in particular argumentative syntheses, have significant epistemic value, as they stimulate students to generalize, rethink and present knowledge in a structured way. Thus, language activity becomes not an auxiliary but a central mechanism of cognition in the study of natural sciences [5].

In this context, the classroom becomes a particularly important environment in which these approaches and practices are implemented. The nature of the interaction between teacher and students influences both the content and the manner of learning. In traditional, teacher-centred learning models, communication is often one-sided, limiting students' ability to participate in dialogue, ask questions and develop their own reasoning. By contrast, a dialogically organised learning process fosters the active use of academic language, contributing to a deeper understanding of scientific concepts and the development of scientific thinking. In this regard, it is important to consider the relationship between scientific thinking and critical thinking, as both are key outcomes of science education. For this reason, their development is also contemplated as among the main objectives of science education. However, in the literature about the two types of thinking in the context of science education, there are quite frequent allusions to one or the other indistinctly to refer to the same cognitive

and metacognitive skills, usually leaving unclear what are their differences and what are their common aspects [6].

In contrast, interactive learning environments promote active participation and collaborative learning, creating conditions for students to be more deeply involved in the learning process. Through discussion, questioning, and peer interaction, students are given the opportunity not only to reproduce information but also to actively rethink it, test their own assumptions, and relate it to scientific explanations. In such an environment, errors are viewed not as obstacles but as important resources for learning, as they open up opportunities to identify and overcome misconceptions. Dialogue, in turn, serves as a key mechanism for co-constructing, refining, and transforming knowledge rather than simply transmitting it from teacher to student. This is especially important for multilingual students, for whom classroom interaction creates additional opportunities to develop both conceptual understanding and academic language proficiency through practical use in a meaningful context.

In addition to verbal interaction, multimodal learning strategies can play an important role in supporting comprehension, especially given the complexity of scientific language. Such strategies involve multiple ways of presenting information, including visual, gestural, symbolic, and empirical components, alongside language. Diagrams, models, digital simulations, graphs, and hands-on experiments can make abstract scientific concepts more tangible and accessible to perception. They promote connections across levels of knowledge representation — from the concrete to the abstract — and help students build holistic mental models. By providing alternative paths to understanding, multimodality can also reduce the cognitive load associated with perceiving complex texts and support students in the initial stages of mastering new terminology and concepts.

At the same time, it is important to realize that multimodal approaches do not eliminate the need for language as the main tool for understanding and communicating scientific knowledge. Any visual or practical representation requires interpretation, which is carried out through linguistic structures and the students' existing knowledge. If these structures are insufficiently formed or contain

inaccuracies, even well-designed visual materials can be misunderstood and, in some cases, reinforce alternative representations. Therefore, effective multimodal learning involves not the isolated use of different forms of information presentation, but their purposeful integration with linguistic support. The teacher should accompany visual and practical elements with clear explanations, focus on key terms and encourage students to verbalize their observations and conclusions. Only under such conditions do different modalities work in harmony, mutually reinforcing each other and contributing to the formation of deep and stable scientific understanding [7].

The recognition that language plays a central role in scientific understanding has significant implications for educational practice. First, teachers must work purposefully and systematically with the language of science, considering both its lexical and discursive levels [8]. This is not just about mastering individual terms, but also about understanding how these terms function in scientific explanations, arguments and models. It is particularly important to make explicit the differences between everyday and scientific meanings of words, since these differences often become a source of misconceptions. Such work involves the use of examples, comparisons, contextualization of concepts and a gradual introduction of students to the specifics of scientific speech.

Empirical research shows that students who can switch flexibly between everyday and scientific language demonstrate a higher level of understanding of the material. On the other hand, those who are limited to spoken language or interpret scientific content exclusively through the prism of everyday experience often find themselves in less favorable conditions for learning. An important factor in success is also the ability to establish connections between words, linguistic expressions and scientific terms, which allows students to effectively discuss, explain and evaluate scientific phenomena. The results indicate significant differences in language use across educational environments and emphasize the importance of discursive practices in the formation of scientific understanding [9].

Secondly, the educational process should involve integrating language and subject components as interconnected aspects of cognition. The separation of these

areas leads to a situation in which students formally master the material but are unable to deeply comprehend or apply it. Integrated approaches, in particular CLIL, create conditions for the simultaneous development of knowledge and language skills, allowing students to master language as a tool for thinking. In such an environment, language ceases to be just a means of transmitting information and becomes a means of constructing knowledge, which significantly enhances the quality of learning [10].

Third, the organization of the classroom environment should promote students' active speech. It is important to create conditions in which they can not only perceive information, but also participate in its discussion, formulate their own explanations, ask questions and critically evaluate ideas. Dialogical forms of learning, group work, argumentative discussions, and joint problem-solving contribute to deeper involvement in the learning process. In such interaction, language acts as a tool of thinking, allowing students to clarify, revise and restructure their own ideas, thereby supporting the process of conceptual change.

Finally, assessment practices should take into account the complex relationship between language and comprehension. Students may demonstrate a sufficient level of conceptual knowledge but may experience difficulty verbalizing it due to limited vocabulary or insufficient mastery of academic structures. In this regard, assessment should be flexible and multidimensional, involving the use of different forms of demonstration of knowledge – oral explanations, visualizations, diagrams, models or written responses of varying levels of complexity. Such an approach provides a fairer and more valid assessment of educational achievement and also contributes to the further development of students' linguistic and cognitive competencies.

Conclusion. A lack of understanding of scientific concepts cannot be explained solely by an insufficient level of knowledge. Language plays a key role in the process of forming scientific understanding. The complexity of academic language, combined with the influence of everyday speech, creates significant barriers to learning. Effective teaching of natural sciences requires integrating linguistic and content components. It is important to consider language as a tool of

thinking that contributes to a deeper assimilation of knowledge.

Thus, the development of academic language competence is a necessary condition for the formation of scientific literacy and successful learning.

REFERENCES

1. Snow C. Academic language and the challenge of reading for learning about science // *Science*. 2010. Vol. 328. P. 450–452.
2. Rao V. The academic language used in scientific research // *Journal for Research Scholars and Professionals of English Language Teaching*. 2022. Vol. 6, Issue 29.
3. Mercer N. *Words and minds: how we use language to think together*. London: Routledge, 2000. 224 p.
4. Coyle D., Hood P., Marsh D. *CLIL: content and language integrated learning*. Cambridge: Cambridge University Press, 2010. 184 p.
5. Casado-Ledesma L., Cuevas I., Martín E. Learning science through argumentative synthesis writing and deliberative dialogues: a comprehensive and effective methodology in secondary education // *Reading and Writing*. 2021. Vol. 36. P. 965–996.
6. García-Carmona A. Scientific thinking and critical thinking in science education // *Science & Education*. 2023. P. 1–19.
7. Kress G. *Multimodality: a social semiotic approach to contemporary communication*. London: Routledge, 2010. 212 p.
8. Schleppegrell M. J. *The knowledge base for language teaching in content areas*. London: Routledge, 2020. 256 p.
9. Larsson N., Jakobsson A. Meaning-making in science from the perspective of students' hybrid language use // *International Journal of Science and Mathematics Education*. 2020. Vol. 18. P. 811–830.
10. Tagnin L., Ní Ríordáin M. Building science through questions in content and language integrated learning (CLIL) classrooms // *International Journal of STEM Education*. 2021. Vol. 8, Article 34.