UNDERSTANDING SCIENTIFIC TEXTS AS A PREREQUISITE FOR SUCCESS IN SCIENCE EDUCATION

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Reading comprehension is a key competence influencing students' success in science education. This study analyzes primary school students' understanding of scientific texts through tasks of varying cognitive demand. It focuses on information retrieval, processing, and interpretation. Three main areas were identified: information retrieval, working with tables, and integration of multiple sources of information. Students achieved high success in tasks based on explicit information, whereas performance declined in tasks requiring interpretation and integration. Error analysis confirmed difficulties mainly in these higher-order cognitive processes. The findings highlight the need for systematic development of reading and scientific literacy through didactic strategies that promote deeper text comprehension. The results are consistent with both national and international research.

Keywords: cognitive demand; information interpretation; primary school students; reading comprehension; science education; scientific literacy; scientific texts.

1 Introduction

Reading literacy is defined as a complex competence encompassing not only the technical ability to decode written text but, above all, the ability to construct meaning from scientific texts, make inferences, and critically evaluate information (Snow, 2002; Rhodes et al., 2025). In science education, this competence is particularly important because students are required to work with textual and graphical representations, interpret experimental results, and formulate scientific conclusions based on evidence (OECD, 2019). Research has also shown that reading literacy is closely related to scientific literacy, which refers to students' ability not only to understand scientific concepts but also to apply them in new contexts and make informed decisions based on scientific evidence (Xie et al., 2023).

International large-scale assessments, such as PISA, systematically monitor the level of scientific literacy among 15-year-old students and confirm that Slovakia's performance remains around the OECD average compared with leading countries such as Finland and Canada, where reading and problem-solving strategies are effectively integrated into science education (OECD, 2019). Empirical studies have also identified specific instructional approaches that can foster the development of this competence, including explicit instruction in metacognitive reading strategies and teaching students how to interpret the structure of scientific texts (Xie et al., 2023).
Reading literacy in science education therefore includes the ability to:

- understand scientific texts (e.g., textbook passages, scientific articles, diagrams, and graphs);
- analyze and synthesize information from multiple sources;
- distinguish facts from interpretations or assumptions;
- interpret quantitative data presented in tables and diagrams;
- apply acquired knowledge to solve authentic problems.

Deficiencies in these competencies may limit students not only in academic settings but also in their ability to think critically about scientific issues encountered in everyday life. Therefore, the integration of reading strategies into science instruction is considered one of the key recommendations of contemporary science education and educational practice (Xie et al., 2023; Rhodes et al., 2025).

2 Relationship between Reading Literacy and Scientific Literacy

Reading literacy and scientific literacy are complementary competencies that mutually reinforce one another in science education. The ability to understand, critically analyze, and synthesize information from textual and multimodal sources is essential for acquiring scientific concepts and applying them in authentic situations (Rhodes et al., 2025; Xie et al., 2023).

A reciprocal relationship exists between reading literacy and scientific literacy. Reading literacy provides the cognitive and linguistic foundation for understanding scientific texts and arguments, whereas scientific literacy offers a meaningful context for developing advanced reading strategies focused on the interpretation of scientific information (Fang & Schleppegrell, 2010; Norris & Phillips, 2003).

Reading literacy involves the active construction of meaning through inferencing (drawing conclusions based on available information), comprehension monitoring, and the critical evaluation of information (Snow, 2002; Perfetti & Stafura, 2014). In the context of science education, this includes the ability to:

- understand scientific and factual texts, such as textbook passages, scientific articles, and laboratory reports;
- extract relevant information from graphs, tables, diagrams, and schematic representations;
- interpret scientific concepts, hypotheses, and argument structures presented in textual and multimodal formats.

Empirical studies indicate that students with well-developed reading literacy demonstrate higher levels of scientific text comprehension and perform better on complex science tasks (Cervetti et al., 2012; Xie et al., 2023). Conversely, poor reading skills are associated with superficial learning approaches and difficulties in formulating explanations and drawing conclusions in scientific contexts.

Scientific literacy refers to students' ability to locate, interpret, and evaluate scientific information, formulate and test hypotheses, and communicate the results of their investigations (OECD, 2019; Xie et al., 2023). At the same time, this process promotes the development of reading literacy by engaging students in activities such as:

- working with various types of texts, including scientific articles, experimental protocols, and research reports;
- critically evaluating evidence, arguments, and methodological approaches presented in scientific literature (Rhodes et al., 2025);
- writing their own scientific reports, arguments, and hypotheses.
- For example, when analyzing a scientific article on climate change, students not only acquire scientific knowledge but also develop higher-order metacognitive processes, such as identifying the main ideas, evaluating the credibility of sources, and constructively comparing alternative interpretations of the findings (Cervetti et al., 2012; Perfetti & Stafura, 2014).

3 How to Support the Mutual Development of Reading and Scientific Literacy?

Supporting the synergistic development of reading and scientific literacy requires systematic integration of activities that simultaneously enhance students' linguistic and cognitive competencies while fostering scientific thinking. Effective approaches include:

- Using authentic scientific texts and systematically analyzing them during science lessons, with an emphasis on identifying argument structures and scientific evidence (Rhodes et al., 2025; Alexander, 2020).
- Working with graphs, tables, and data visualizations, which promotes the simultaneous reading of texts and the inferential processing of data (Rhodes et al., 2025).
- Engaging students in discussions and argumentation activities on scientific topics, encouraging them to formulate and defend their interpretations based on textual and data sources (Perfetti & Stafura, 2014).
- Writing research reports and formulating hypotheses, enabling students to transform their understanding into their own written texts and scientific arguments (Xie et al., 2023).

Integrating these approaches into school practice not only improves students' achievement in science subjects but also strengthens their ability to critically evaluate scientific information in everyday life, thereby making a significant contribution to the development of lifelong literacy.

4 Research Design and Methodology

The study focused on analyzing the level of students' reading literacy in the context of science education, with particular emphasis on their ability to retrieve and process information from different types of sources. The empirical investigation was conducted using three comprehensive tasks that simulated authentic situations involving scientific texts, tabular data, and combined information sources.

4.1 Implementation of the Tasks in the Teaching Process

The tasks were designed as multidisciplinary activities integrating knowledge from biology, chemistry, physics, mathematics, and geography. Each task included an introductory scientific text followed by a variety of closed-ended and open-ended questions aimed at interpreting data, performing calculations, analyzing experimental situations, and explaining natural phenomena.

The first comprehensive task, Photosynthesis – The Basis of Life on Earth, was designed for students in Grades 6–7 of primary school. The task belongs to the topic of plant life and is primarily intended for biology lessons. Within the third educational cycle, it can be incorporated into thematic units dealing with plant and animal life processes and energy transformations in nature. The biological component focuses on the process of photosynthesis, the role of chlorophyll, the importance of carbon dioxide and water in the production of organic substances, and the significance of photosynthesis for food chains and ecosystem functioning.

In addition to biology, the task naturally integrates several other subjects. From a physics perspective, students encounter the concept of light as electromagnetic radiation and as the energy source required for photosynthesis. The chemistry component involves interpreting the chemical equation of photosynthesis and calculating the amounts of carbon dioxide consumed and oxygen released. Mathematics is applied through the interpretation of tables, calculations of mass changes, and solving simple numerical problems. The geographical dimension is reflected in interpreting the distribution of photosynthetic organisms across different regions of the world and explaining the importance of ecosystems in global biogeochemical cycles.

The second comprehensive task, Corrosion of Iron and Steel Structures, was designed for students in Grades 8–9 of primary school. It is primarily intended for chemistry lessons covering topics such as chemical reactions of metals, oxidation and reduction, and materials and their properties. The task focuses on the mechanism of metal corrosion, the influence of environmental conditions on corrosion rates, and methods of protecting metal structures.

Its multidisciplinary nature is also evident in its links to other school subjects. Mathematics is applied in calculating the percentage of metal mass loss and determining corrosion rates over time. Physics contributes concepts related to electrochemical processes and the principles of galvanic cells. Geography and social studies are incorporated through the analysis of the economic consequences of corrosion and the identification of industrial sectors in which corrosion causes significant financial losses.

The third comprehensive task, Cholesterol and Heart Health, was designed for students in Grades 8–9 of primary school. It is particularly suitable for biology lessons focusing on the human body, metabolism, and disease prevention. The task addresses the biological function of cholesterol, the differences between LDL and HDL cholesterol, the development of atherosclerosis, and the importance of a healthy lifestyle in preventing cardiovascular diseases.

This task is likewise strongly interdisciplinary. The chemistry component focuses on lipids and their functions in the human body. Mathematics is used in calculating percentage increases in cholesterol levels, estimating energy intake, and determining dietary fat consumption. Physics concepts are applied when explaining blood pressure as a physical quantity acting on the walls of blood vessels. Geographical aspects are reflected in the interpretation of regional differences in the prevalence of cardiovascular diseases worldwide.

The implementation of such comprehensive tasks in science teaching promotes active learning and supports students in integrating knowledge from different scientific disciplines. While solving these tasks, students learn to analyze texts, interpret data, perform calculations, and explain natural phenomena within broader scientific contexts. At the same time, they develop an awareness of the practical importance of scientific knowledge for everyday life, environmental protection, and personal health.

The questions accompanying the tasks were diverse and assessed multiple levels of students' knowledge and skills. They included multiple-choice questions aimed at identifying correct answers, completion and calculation tasks integrating scientific and mathematical skills, and matching tasks designed to assess conceptual understanding. The assessment also included true/false questions that examined students' understanding of relationships and open-ended questions requiring explanations of phenomena and the proposal of solutions. Some tasks combined data analysis and interpretation with brief written justifications. Overall, the tasks covered a broad range of cognitive processes, from remembering and understanding to application, analysis, and evaluation.

4.2 Research Objective

The main objective of the study was to identify students' level of mastery of the individual components of the information acquisition competency (information retrieval, selection, integration, and interpretation) and to analyze the typical errors students make when solving complex tasks in a science context.

4.3 Research Questions

Based on the research objective, the following research questions were formulated:

1. What is the level of students' success in solving tasks focused on information retrieval from texts, working with tables, and integrating information from multiple sources?
2. Which component of information acquisition competency presents the greatest difficulty for students?
3. What types of errors occur when students solve the individual tasks, and at which stage of information processing (retrieval, selection, integration, or interpretation) do these errors occur?

4. How does task complexity (simple versus integrated tasks) affect students' success?

4.4 Description of the Research Sample

The research sample consisted of 62 eighth-grade primary school students. A purposive sampling method was used, and all participants attended regular primary school classes.
The students were approximately 13–14 years old, corresponding to the lower secondary level of education. This age group was selected because students at this stage are expected to possess basic reading strategies while simultaneously encountering increasingly demanding scientific texts in science subjects.

The research sample constituted a homogeneous group in terms of educational level, enabling comparisons of students' performance across different task types and the identification of common difficulties in information processing within the target population.

4.5 Research Instrument

The research instrument was a test consisting of three comprehensive tasks, each comprising several sub-items designed to assess different aspects of reading literacy in a science context. The tasks were designed to assess:

- comprehension of continuous texts (information retrieval and comprehension);
- interpretation of non-continuous texts (tables and graphs);
- integration and interpretation of information from multiple sources.

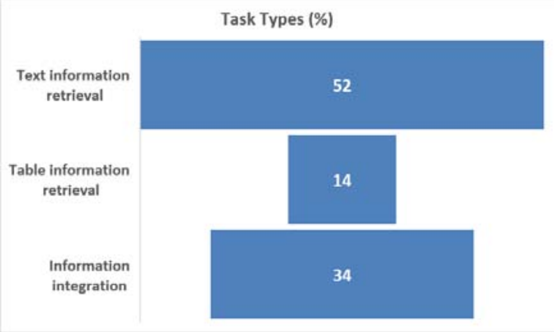
The study employed a mixed-methods research design, combining quantitative and qualitative approaches. The quantitative analysis focused on students' performance on the different task types and the percentage of correct responses. The qualitative analysis examined and categorized students' errors, identifying the stage of information processing—retrieval, selection, integration, or interpretation—at which failures most frequently occurred.

The proposed research design made it possible to comprehensively assess students' reading literacy through authentic tasks simulating real-life situations involving scientific information. At the same time, it provided detailed insights into students' problem-solving processes and identified the critical stages that represent the greatest barriers to effective information processing in science education.

5 Analysis of the Research Results

Based on the analysis of students' responses to the individual sub-tasks, three main categories of activities within the information acquisition competency were identified: (1) information retrieval from text, (2) working with tabular data, and (3) identifying and integrating information from multiple sources. These categories accounted for 52% of the tasks focused on text-based information retrieval, 14% of the tasks involving tabular data, and 34% of the tasks requiring the integration of information from multiple sources.

Figure 1. Distribution of Information Acquisition Task Types



Information Retrieval from Text
The first category included tasks focused on identifying specific information in a text, including both explicit and implicitly presented information, definitions of scientific concepts, and the selection of information according to specified criteria. The average success rate reached 83.76%, indicating the relatively low cognitive demand of these tasks. Nevertheless, students experienced difficulties with tasks requiring the identification of complex information consisting of multiple elements. In such cases, they often provided only partial answers and failed to identify all relevant information, particularly when multiple selection criteria had to be applied.

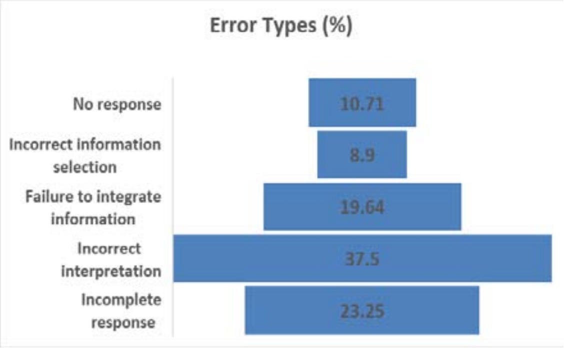
Working with Tabular Data
The second category consisted of tasks focused on retrieving information from tables as a specific form of data representation. This category achieved the highest success rate (93%), suggesting that students were relatively successful in directly locating information in structured formats. However, performance declined in tasks requiring the simultaneous identification of multiple data points or their integration with other information sources, indicating limitations in more complex information processing.

Integration of Multiple Sources of Information
The lowest success rate (71.43%) was recorded in the third category of tasks, which required students not only to identify relevant information but also to integrate and interpret it. These tasks represented a higher level of cognitive demand because they required the integration of multiple sources of information into a coherent whole. The results suggest that this stage of information processing presents the greatest challenge for students.

Error Analysis
To identify the sources of students' difficulties, a detailed analysis of incorrect responses was conducted. Incorrect responses accounted for 19.05% of all responses. Based on the nature of the errors, these responses were classified into five categories:

- No response (10.71%) – no answer was provided, most likely due to uncertainty or misunderstanding of the task.
- Incorrect information selection (8.9%) – identification of irrelevant or incorrect information despite working with the source material.
- Failure to integrate information (19.64%) – inability to combine multiple correct pieces of information into a coherent response.
- Incorrect interpretation (37.5%) – the most frequent type of error, resulting from misunderstanding the meaning of the identified information.
- Incomplete response (23.25%) – providing only part of the required information without addressing all aspects of the task.

Figure 2. Distribution of Error Types in Students' Responses



The analysis showed that failures occurred at different stages of information processing, ranging from information retrieval and selection to integration and interpretation. The predominance of errors in the categories of interpretation and information integration indicates that students' main difficulties lie not in retrieving information itself but in achieving a deeper understanding and processing of that information.

6 Discussion

The findings indicate that students' performance declines significantly as the cognitive demand of the tasks increases, highlighting the difference between solving simple and complex (integrated) tasks. Students achieved the highest scores on tasks based on the straightforward retrieval of explicitly presented information, such as locating specific data in tables, where no deeper processing was required. In contrast, the greatest difficulties were observed in tasks requiring the integration of multiple pieces of information, the establishment of relationships among them, and their subsequent interpretation. Such tasks involve higher-order cognitive processes, including inference, synthesis, and evaluation. This trend suggests that students have less developed skills for working with complex texts and solving tasks that extend beyond the level of basic comprehension. From a pedagogical perspective, these findings emphasize the need for the systematic development of higher levels of reading literacy, particularly through tasks that promote critical thinking and the integration of information from multiple sources.

The observed differences between students' performance on lower-order and higher-order tasks support current theoretical perspectives on reading comprehension. While students demonstrated satisfactory performance when retrieving explicitly stated information, considerably lower success rates were found in tasks requiring inference, integration, and interpretation. According to Perfetti and Stafura (2014), successful reading comprehension depends not only on decoding and vocabulary knowledge but also on the ability to construct coherent mental representations of text by integrating multiple sources of information. Similarly, Snow (2002) emphasizes that deeper comprehension requires readers to generate inferences and actively connect new information with their prior knowledge. The present findings are consistent with these theoretical assumptions, suggesting that students' difficulties arise primarily during higher-level cognitive processing rather than during basic information retrieval.

It is also important to consider the organizational conditions of the study, particularly the 30-minute time limit, which may have negatively affected students' performance on more demanding tasks, as these require more time for processing. This may have contributed to the higher frequency of incomplete responses or unanswered items, reflecting not only a lack of knowledge but also insufficient time to carefully consider and formulate a response.

7 Conclusion

The findings of this study indicate that students achieved the highest success rates on tasks focused on simple information retrieval, particularly from structured formats such as tables, confirming their ability to work with explicitly presented information. However, as the cognitive demand of the tasks increased, students' performance declined considerably. The greatest difficulties were observed in tasks requiring the integration, connection, and interpretation of multiple pieces of information.

The error analysis further revealed that the primary challenge was not information retrieval itself but rather the correct understanding and processing of information. This was reflected in the high proportion of errors related to interpretation and the failure to integrate information. The findings highlight the need for the systematic development of higher-order cognitive processes, particularly inference, synthesis, and critical thinking, which are essential for effective comprehension of scientific texts in science education. At the same time, the influence of organizational factors, such as the time limit, should also be considered, as it may have affected students' performance on more demanding tasks.

These findings are consistent with both national and international research. In Slovakia, Gavora (2012) identifies reading comprehension as a fundamental student competence, while Lapitková et al. (2015) and Held et al. (2011) emphasize its importance for the interpretation of scientific information and the development of scientific literacy. Similarly, Dobišová Adame et al. (2020) highlight the need to connect reading comprehension with the practical application of knowledge in science contexts.

Likewise, international researchers (Norris & Phillips, 2003; Phillips & Norris, 2009) argue that reading literacy is an integral component of scientific literacy and that understanding the language of science is essential for learning. Empirical studies (Dori et al., 2018; Cromley & Azevedo, 2007) demonstrate that the development of metacognitive strategies and text-based learning improves students' comprehension and academic achievement, while broader conceptions of scientific literacy (Laugksch, 2000; Guthrie, 2004; Snow, 2002) emphasize the importance of active information processing, motivation, and inferential reasoning.

From an educational perspective, these findings highlight the importance of systematically incorporating reading strategies into science instruction. Rather than focusing exclusively on factual knowledge, science teachers should provide students with regular opportunities to analyse scientific texts, compare information from different representations, and justify their conclusions using evidence. Such instructional approaches have been shown to improve both reading comprehension and scientific literacy (Cervetti et al., 2012; Xie et al., 2023). Moreover, integrating authentic scientific texts and inquiry-based activities into classroom practice may strengthen students' ability to transfer reading skills to complex scientific contexts (Rhodes et al., 2025).

Overall, the findings suggest that although students are proficient in basic information-processing tasks, greater emphasis should be placed on developing their ability to work with complex information, integrate information from multiple sources, and interpret it within broader contexts. These competencies represent a fundamental prerequisite for the development of both scientific literacy and reading literacy.

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