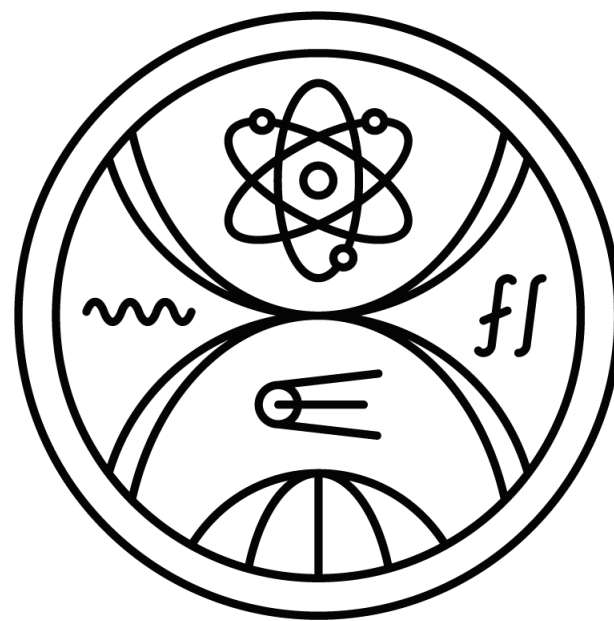




Analysis of Tasks and Pupils' Solutions at the International Junior Science Olympiad from the Perspective of Cognitive Processes

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Introduction

The paper presents the results of an analysis of the performance of pupils who participated in the international rounds of the International Junior Science Olympiad (IJSO) in 2023 and 2024 (six pupils each year). The aim of the analysis was to find out how the selected sample of Slovak pupils performed in standardized tests, more precisely – to what extent the pupils lacked the ability to use certain cognitive processes defined by Anderson and Krathwohl [1], building on Bloom's taxonomy [2], when solving physics problems. The analysis also aimed to examine the kinds of physics tasks to which the pupils were exposed. Therefore, the paper provides a comprehensive summary of the nature of the tasks given to pupils at the IJSO and how the selected Slovak pupils approached these tasks in 2023 and 2024. Based on the analysis, Slovak pupils showed relatively consistent performance in tasks requiring the Applying level of cognitive processes; however, they had difficulties with tasks involving higher cognitive processes, such as Analyzing.

Cognitive processes of Revised Bloom's Taxonomy

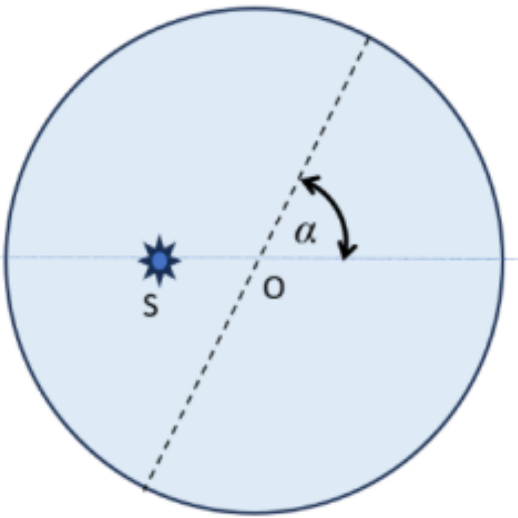


International Junior Science Olympiad

An annual science competition for pupils under 16, testing their knowledge in physics, chemistry, and biology through theoretical and practical exams. It consists of 3 parts:

- **Multiple Choice Exam (MSQ)** (~1.5 to 2 hours):
 - ~30 multiple-choice questions.
- **Theory Exam – Structured Questions** (~3 hours):
 - Typically 3 integrated problems, each with multiple subparts.
- **Experimental Exam – Practical Test** (~3 to 4 hours):
 - Pupils work in **teams of 3**, conducting one or more experiments.

A point light source S is located inside a sphere with a radius R , at a distance $OS = d = \frac{2}{\sqrt{6}}R$ from its center. The relative refractive index of the sphere with respect to the external medium is $n = \sqrt{2}$. Not taking reflexion under consideration, the central angle α of the sphere corresponding to the points on the surface through which light does not exit is:



- A. $\alpha \in (45^\circ, 135^\circ)$
- B. $\alpha \in (60^\circ, 120^\circ)$
- C. $\alpha \in (75^\circ, 105^\circ)$
- D. $\alpha \in (105^\circ, 165^\circ)$

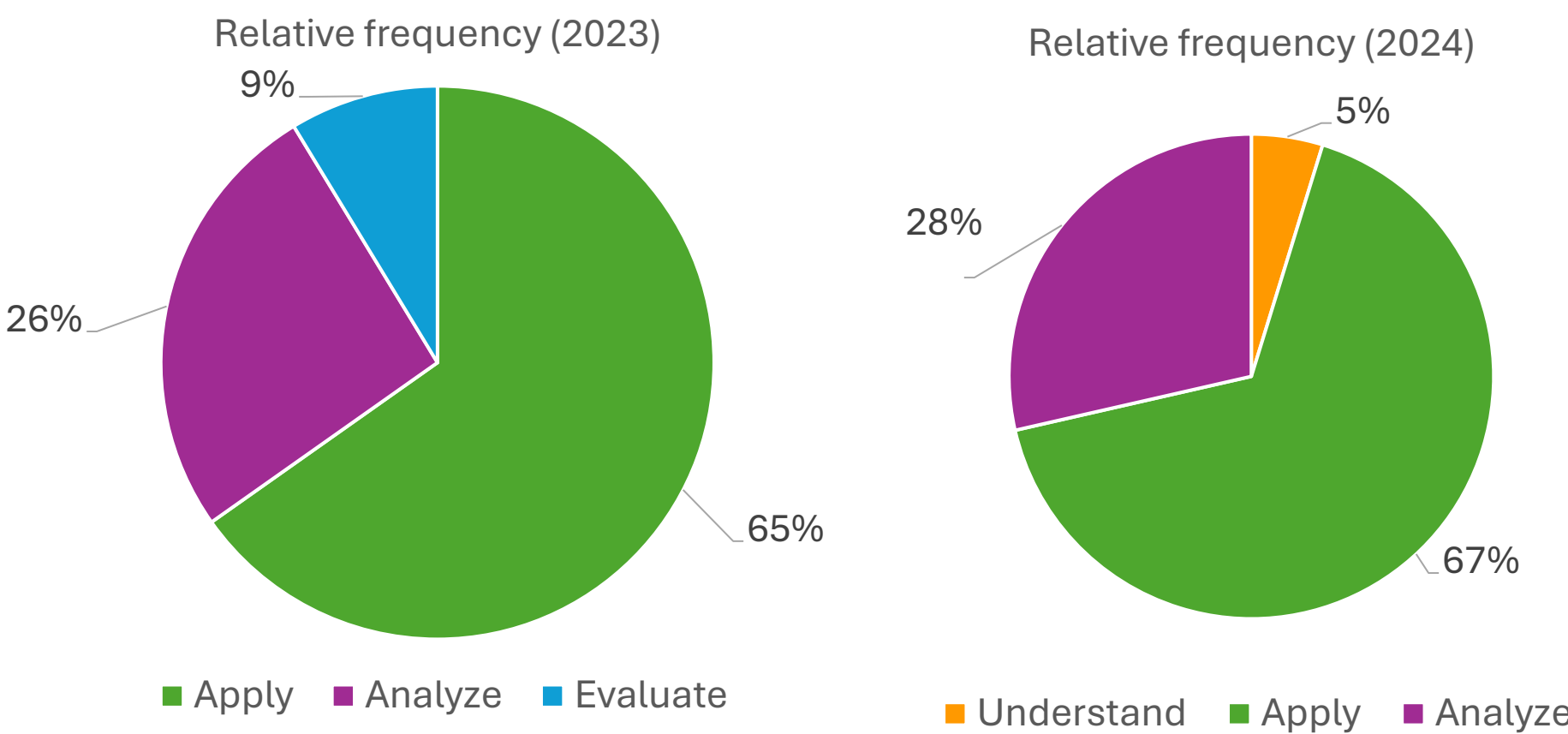
Methodology and results

During the analysis of IJSO problems from the years 2023 and 2024, we examined each problem through the lens of cognitive processes as defined by the RBT framework. The analysis involved the following steps:

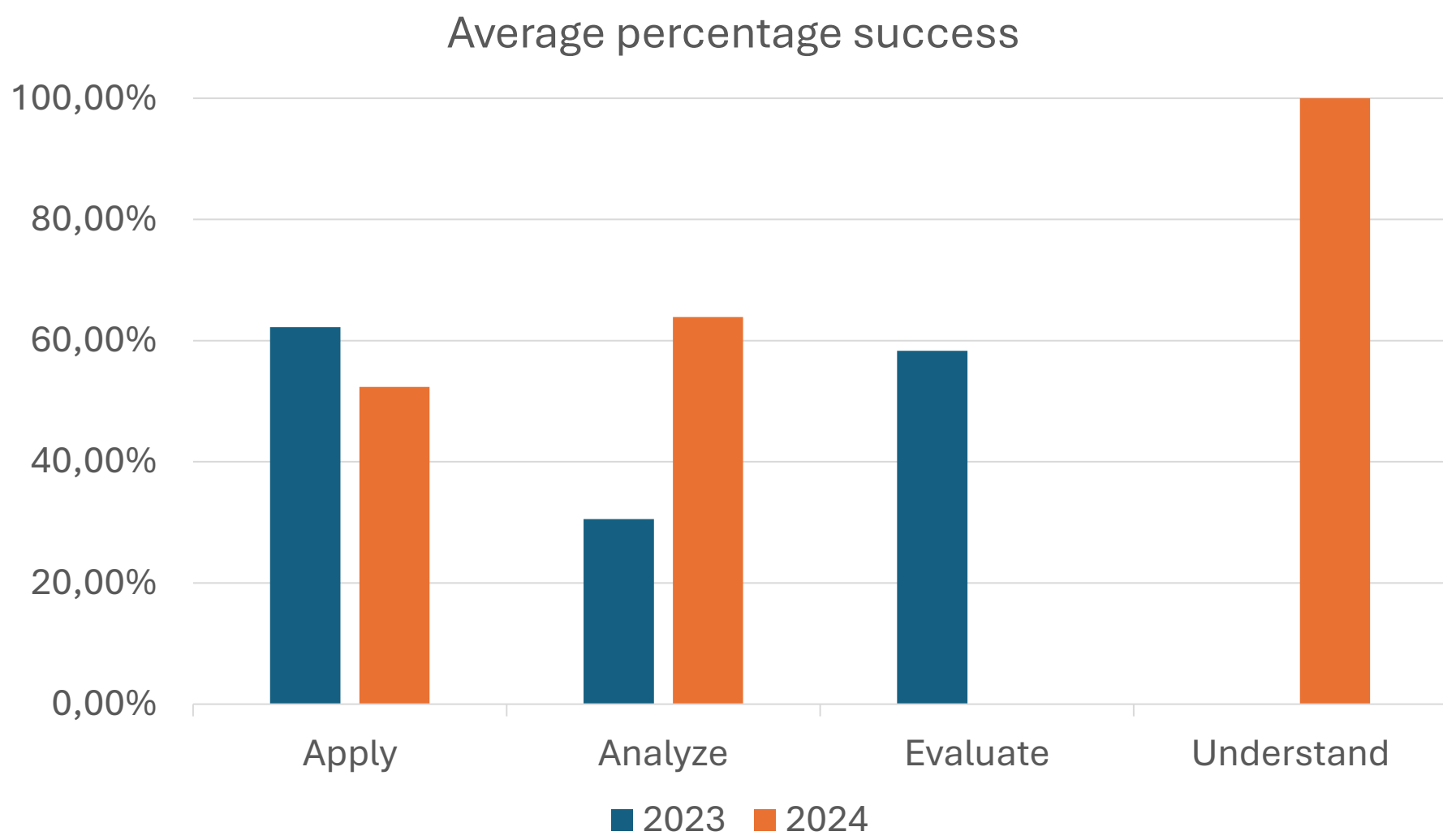
- Identifying the key cognitive process required for solving each problem—the one primarily being assessed.
- Calculating the percentage distribution of the different cognitive processes across all problems.
- Evaluating each pupil's work based on the correct application of the intended cognitive process, rather than solely on arriving at the correct final answer.
 - Numerical mistakes or incomplete solutions (due to time constraints) were not treated as failures, provided the correct cognitive process was demonstrated.
 - Each subpart of multi-part problems (a, b, etc.) was treated as a separate task for the purposes of analysis.

Results

According to the analysis, the 2023 and 2024 physics problems (MSQ and Theory) primarily emphasized the cognitive processes of applying and analyzing, with a minor focus on evaluating in 2023 and understanding in 2024.



It is clear that different pupils do not perform equally across various cognitive processes. Moreover, even within the same cognitive process, there is noticeable variation in pupils' abilities from year to year.



Conclusion

As shown earlier, the distribution of cognitive processes in IJSO questions varies depending on the organizers and their committees. Despite this, questions in the last two years have mostly focused on application and analysis. Slovak pupils showed relatively stable performance in application-type tasks (62,22 % and 52,38 %), but were less consistent in tasks requiring analysis (30,56 % and 63,89 %). Although results in evaluation- and analysis-oriented problems look promising, the limited number of such tasks prevents meaningful comparison over time. These results however indicate that there is a need for revising the processes of preparation of pupils for IJSO in order to achieve better results.

References

[1] Anderson, L. W., Krathwohl, D. R., 2001, *A Taxonomy for Learning, Teaching, and Assessing*. Available online: <https://shorturl.at/TErFJ>.

[2] Bloom, B. S. et al., 1964, *Taxonomy of Educational Objectives*. Available online: https://archive.org/details/taxonomyofeducat0000bloo_o9o7/page/196/mode/2up.