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Children's Understanding of Thermal Phenomena in Initial Science Instruction

Extended summary

Despite the influence of teaching, the ways how students in primary science education interpret and understand concepts about heat are often opposed to the scientifically based concepts. The method of interpretation of thermal phenomena in primary teaching, that avoids scientific explanation based on the particle structure of substance, enables the formation of students' alternative ideas. In order to successfully interpret complex scientific concepts in primary science education, it is necessary, first of all, to gain insights into alternative ways of students' understanding the concepts. There are numerous studies that identify the existence of children's alternative ideas about thermal phenomena and processes, as well as the effects of the application of teaching models that try to overcome unscientific ideas (Erickson, 1979; Haglund et al., 2012; Kampeza et al., 2016; Gerháťová et al., 2021).

The aim of this study was to determine the level of students' understanding of thermal phenomena, and therefore, the following hypotheses were set: It is assumed that students, from the first to the fourth grade of primary school, are not completely capable of giving scientifically accurate answers about the states of matter, structure of substance, temperature, heat, conduction of heat, and global warming of the Earth; It is assumed that students' achievement decreases as the cognitive level of the task increases; It is assumed that there are statistically significant differences in the achievements of students of different age groups. Thus, we created a knowledge test that included the concepts of the structure of substance and thermal phenomena. Students' answers were grouped into categories from 1 to 5, with the percentage of correct

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answers on the test increasing by 20% as the category increases. The research was carried out in primary schools in two cities, Sombor and Kikinda, and the sample consisted of 475 students.

The study has confirmed unsatisfactory achievements of students on the knowledge tests about thermal phenomena, which is in line with the previously published research (Haeu-sler& Donovan, 2017). The average number of points for the entire sample was 13.53 out of a maximum of 40. The analysis of the students' achievements for the entire sample by category has shown that two-fifths of students were in the category 2, while approximately one quarter of students were in categories 1 and 3. Less than 10% of the students were in category 4, while there were no students in category 5. Obviously, more than 90% of the respondents solved the test at the level of the first three categories (maximum 60% of the tasks on the test). A comparative analysis of students' achievement for the entire sample demonstrated that, with some exceptions, with the increase in the cognitive level of demands in the tasks, there was an increase in the percentage of students who did not give the correct answer to the question, while at the same time the percentage of students who gave completely correct answers decreased. Similar outcomes were previously demonstrated by other studies (Fardin&Radmehr, 2013; Cvjetićanin et al., 2015). According to the obtained results, the lowest achievement (category 1), a score between 0-20% of the maximum number of points, was more frequent among the first and the second-grade students than among the higher grades students. In all grades, the majority of students scored between 20-40% (category 2), while the majority of the third and the fourth grades students scored between 40-80% of the maximum number of points (categories 3&4). The highest score was not obtained (category 5). There was no significant difference between the first and the second or between the third and the fourth-grade students, whereas this difference was statistically significant in other pairs of grades (in favour of higher grades). The highest achievement on the knowledge test were accomplished by the third-grade students, which correlates with the fact that most of the teaching content related to thermal phenomena is thought within the subject Science and Social Studies in this grade. The students of the first and the second- grades had not yet become familiar with these contents, but solved the test utilizing experiential knowledge, while the students of the fourth grade obviously did not permanently adopt the knowledge acquired during their previous education.

The obtained results revealed that the students from the first to the fourth grades were not capable of providing scientifically accurate answers about the selected thermal phenomena and processes. The observed differences in achievement were related to different age groups of students and to the tasks representing different cognitive levels. Moreover, the study has confirmed that there was an insufficient impact of instruction at the level of thermal phenomena understanding, indicating a necessity for new approaches to the primary instruction of the aforementioned content.

Keywords: initial science instruction, thermal phenomena, pupils' achievement, test of knowledge

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