

The size of objects as a fundamental concept of nanotechnologies in Czech middle school physics curriculum

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Abstract. Nowadays, there are various science disciplines in which the most dynamic advancement occurs. Nanotechnologies belong among these rapidly developing fields of research. For understanding nanotechnologies, it is important to know how small is a nanometer. Students have a problem to assign the size of objects smaller than one millimeter. The concept of nanotechnologies as the size of objects is not a part of Czech middle school physics curriculum but it can be integrated into regular curriculum through appropriate activities integrated into the lesson where the students get familiarized with units of length.

1 Dynamic development in science

Nowadays, there are various science disciplines in which the most dynamic advancement occurs. This dynamic development generates original scientific knowledge enriching and changing paradigm of different fields of science. The findings are created by research and are mostly presented as articles in renowned scientific journals. Due to many reasons such as motivation for scientific study, it is important to mediate scientific knowledge to students. The process of mediating this knowledge to students is crucial for updating the curriculum of all the types of schools. The updating places in curriculum can be called as dynamic places of curriculum. Presentation of topics connected with dynamic curriculum places can be difficult for science teachers. Thus, these topics could be a domain of science centers and the current scientific knowledge also could be presented to the general public. [1]

2 Potential of nanotechnologies

Nanotechnologies belong among these rapidly developing fields of research. The products of nanotechnologies are not just in the laboratories, but some consumer products containing nanomaterials or made using tools of nanotechnologies can be already found in many shops. In this field of research, scientists work and manipulate with the material that measures only a few nanometers. The potential of nanomaterial comes from its tiny size. Some materials have novel properties at the nanoscale, allowing creation of new materials and devices. [2]

2.1 *The size of the objects*

For understanding nanotechnologies, it is important to know how small is a nanometer. The size of object belongs among eight big ideas of nanoscale science and engineering published in guidebook for secondary teachers where each idea was examined. Students know the size of some objects from their experience because they can see them with their eyes. They learn, for

example, that an ant is much smaller than an elephant. But they have a problem to assign the size of objects smaller than one millimeter. The study of objects at the microscale and nanoscale requires special tools. The fundamental concepts of nanotechnologies as the size of objects are not a part of Czech middle and high school physics curriculum but they can be integrated into regular curriculum to appropriate places. The beginning of integration of concept is possible in the middle school. This concept can be included in the topic Measured quantities – length and States of substances in 6th grade. Because this concept has received a great attention in learning-related research in nanotechnology education, many teaching materials and articles have been created worldwide. [3,4]

2.2 *The activities for classroom*

Most of teaching and learning materials were in English language and thus, it was necessary to adapt all activities for the Czech classroom. Activities were integrated into the lesson where the students get familiarized with units of length. For example, in one activity, students received two kinds of cards – with different-sized objects or different distances and with units of length. The goal of the activity was to find the right size to each object and sort objects from the largest one to the smallest one. In the end, students watched the famous video *Powers of Ten*, controlled the past activity and wrote the right sizes of different objects to the worksheet. In other task students should find right pair of objects in macroscale and microscale. [5,6]

In the beginning of the lesson, students wrote the pre-test in which they should assign objects or distances to the length units. They did not want to write test because they were not sure about the answers. After lesson with activities students' perception of sizes has improved.

3 Conclusion

The activities took place in three classrooms in one middle school with 61 participants. Some activities were tested with small groups of students in the local science center but these students did not write pre-test and post-test. All students were involved in lessons and they were proud of their progress of understanding the right size of the objects. An activity with two kinds of cards is also very popular with other teachers and their students. The lessons about length of things are more interesting for students with size activities than only with unit conversion.

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