Developing Pupils' Ideas related to the Concept of Force in the 1st Year of Gymnasium

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Abstract. This contribution offers preliminary ideas for creating a part of a higher secondary school educational program aimed at the holistic development of students. The ideas we illustrate by development of the concept of force, as found in several traditional topics of physics education. We ground our work on the neuroscience view of learning as formulated by T. Tokuhama-Espinosa, and the concept of force development we ground on the fact that pupils commonly encounter it in everyday life. We also illustrate the target level, where we want students to get, and an example of activity used in such development.

The concept of force

The concept of force is one of the core concepts of secondary school physics, especially mechanics. The main topic of this contribution is not research, how to learn or how to teach secondary school mechanics, but how to use development of concept of force in holistic student development, at the age of 15. To illustrate procedures involved in development of school educational program, we have selected the concept of force as students consciously and unconsciously encounter this concept every day in their everyday lives. Without force, it would be impossible to get out of bed in the morning, walk, drive, write, etc. In this contribution, we try to use procedures applicable to the development of other similarly broad concepts, such as the concept of energy, sound, or light.

The concept of force serves us as a mean for the development of pupils not only in terms of knowledge. The goal of teaching physics is not for students to memorize as many definitions of quantities and phenomena as possible. In physics, we teach students to think, think about things logically and apply elements of scientists' work. We want students to be able to look for connections, analogies and interdependencies between individual physical quantities and phenomena. One of the goals is to teach students to identify the concepts they learn in complex situations, which is missing in most of the previous concept tests. Nowadays, the teacher has many conveniences with which he can make the teaching of physics meaningful [1], examples of which can be various sensors and software. In this contribution, we present an activity using a force sensor. During concept formation it is also important for a teacher to distinguish between concepts as interest, motivation and engagement [2]. The independent work of students and the discovery of a new knowledge based on their own experience is also essential [3].

Ideas for creating part of the school educational program

Using the concept of force, we offer several approaches selected to creation of a part of the school educational program for the 1st year of grammar school. We focus on how to develop a student so, that, after completing physics education, he becomes generally educated person. We try to describe the selected approaches in such a way that they are applicable to any other topic in physics. Intensive research based on the development of medical imaging and artificial intelligence in the last decades improved our vision of how children learn. In addition, of course, more than a century of research on general education, educational psychology, pedagogy, science education, and physics education has brought deep knowledge on how children learn physics. However, we see that the neuroscience research results bring new light to some aspects of learning. Moreover,

there are more successful neuroscience research teams. In our work, we focus on the research of the team around T. Tokuhama-Espinosa [4], a professor at Harvard University researching in the field of neuroscience of learning, and C. R. Cloninger, professor emeritus at Washington University researching in the field of the psycho-socio-biological model of personality and science of well-being [5]. We apply these to the analysis of methods that physics teachers use to educate pupils at the age of 15.

Methodology

In this contribution we present preliminary ideas related to design of school program aimed at holistic development of students. Concept of force development is used for illustration of general ideas. Theoretical work is supplemented with results of one year preliminary research on a sample of two classes of the age of 15. Firstly, we have defined the output level at the graduation (at the age of 18), this level will be illustrated in the contribution. Secondly, we have prepared input test, where we tried to grasp the level of our students – graduates of various lower secondary schools. Based on input knowledge and vision of the graduation level, we designed and carried out a series of lessons for four months physics course, and tried to develop the concept of force regarding to the vision of our innovative school and to the holistic approach in learning. Then we used output test on the same sample of students to find out the output knowledge and abilities to use the knowledge in complex situations.

Conclusion

Based on out theoretical research, as well as preliminary one year research realized on two classes, we can conclude, that new knowledge of theories of physics education and educational neurosciences have potential to add new impetus to design of school educational program in physics. Well balanced activities can have potential to holistically develop students and leverage their concept formation. In the contribution we present nice improvement on the way from naïve to normative force concept use not only in a straightforward test questions, but also in analysis of complex, for the students new, contexts. Ads the conclusion, we will formulate also some research questions aroused within our preliminary research.

References

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