In-service Physics Teachers and use of Sensors in the Light of Principles and Tenets of Human Learning

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Abstract. Sensors specially designed for use in schools to measure values of physical quantities within science education have its firm place in the theory of science education for some decades already. However, there are many teachers and schools where sensors are not used. Some schools do not use any sensors, and others use sensors designed for industrial use. In this contribution, the effective use of sensors is discussed in the light of principles and tenets of human learning, as proposed by colleagues researching the application of neuroscience to education. The focus is put on in-service physics teachers training.

1 Principles of human learning and neuroscience

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, 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.

Tokuhama-Espinosa, with her team, identified 6 principles and 21 tenets of human learning. In the this contribution, we apply these to learning physics concepts by the children aged 12-16, using sensors developed for measurement values of temperature and force.

1.1 Principle 1, Uniqueness

Human brains are unique; no two brains are the same. So, when we set standards for pupils, we must keep in mind that pupils are unique. Not all children are good at all things. So the education and the evaluation of pupils' performance must be differentiated. Some children need more attention, and others need more rehearsal on a particular concept [1]. The classroom must be flexible to allow the development of most of (ideally all) the pupils. As an example of the fulfilment of this principle, we present an activity focused on developing the idea of sampling frequency. Pupils of the age of 12, in the early weeks of the 6th grade, perform a team activity concentrating on measuring the temperature of two glass containers with water, one cold and the second warm; each group of 4 pupils in the class use one digital thermometer. We use a thermometer connected to the interface and computer, but we also have experience with the activity performed with cheap digital thermometers.

In the final contribution, we discuss the principle of uniqueness applied in the activity context.

1.2 Principle 2, Different potentials

Each individual's brain is differently prepared to learn different tasks. Learning is shaped by the context of the learning, prior learning experiences, personal choice, an individual's biology and genetic make-up, and environmental exposures.

1.3 Principle 3, Prior experience

It seems to be no doubt that new learning is influenced by prior experience. The brain's efficiency economizes effort and energy by ensuring that external stimuli are first decoded, compared with existing memories, both passively and actively. For a teacher, it is a great advantage to know as much as possible about the prior experiences of his pupils. Still, there are many unknowns. Even a pupil sometimes do not know all about his prior experiences. Here we use, as an example, pupils who have performed the activity with temperature measurement and sampling frequency experiencing used as the example in principle 1. Pupils well focused on the process of time measurement, prompt to read value, writing the value to the correct row of the table, … much better feel time-based measurement of temperature and other quantities, when the sampling frequency is set in the software and reading values at regular time intervals is made by the data-logger or computer.

Taking into account prior experience is a base of all curricula. Usually, we have used such principle for linking-up quantities to be taught "in a proper order". In the last decades, we have applied this principle more to the skills. For example, recently we have realised research on so-called "inventorially oriented project", with pupils of the age of 12. Pupils were instructed to prepare a functional prototype of a product and use any knowledge and equipment. Two years after realising these projects, most of the pupils could remember the project and some details. The experience from these 7 lessons was used many times during physics education. How they used such experience outside physics education, we did not examine.

2 Conclusion

Working with physics teachers has found the principles and tenets of human learning, as formulated in [1], valuable. Therefore, some real conclusions is developed.

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References

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