Measuring time - from sundials to exploring the pendulum

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Abstract. The workshop offers a research activity designed for the first year of lower secondary school on the topic of timekeeping. Students create a non-linear graph from their own data and discuss its properties. They reflect on the exploratory cognitive cycle and become aware of the knowledge, skills and competences they have acquired during their learning. Workshop participants will first go through the lesson as learners and then discuss its relevance from the teacher's perspective.

Introduction

The measurement of physical quantities is a common part of the first year of physics education at school in the Czech Republic (usually for pupils aged 12-13). Pupils are introduced to measuring length, volume, mass, temperature and, of course, time. Pupils learn how historical clocks work (sundial, water clock, candle clock, ...), sometimes they even make their own simple clocks and learn to convert units of time. However, this thematic unit also offers a much more challenging but very useful activity for further study of physics – exploring the pendulum. Part of this activity is also the creation of a graph from the measured data, probably the first opportunity for students of this age group. At the same time, working with graphs is an important skill that needs to be trained and strengthened in teaching [1-2].

Objectives of the activity, its content

This is one of the first truly exploratory activities in the Heureka project [3]. Under the guidance of a teacher, the pupils investigate the behaviour of a pendulum, which is a fundamental element of a mechanical clock. First, they are introduced to the pendulum, which is realized by a weight on a thread. Next, they discuss what quantities could be measured and suggest what properties the pendulum's swinging might depend on. They then test their hypotheses. It comes as a great surprise to them that the swing of the pendulum does not depend on the mass of the weight, but only on the length of the suspension (and of course gravity). In the next lesson, they work in pairs to investigate the dependence of the number of oscillations in ten seconds, on the length of the pendulum for two different lengths (Fig. 1). Each pair writes their results in a common table, so the whole class collects about 30 values for a range of lengths from about 10 cm to 2 metres. The students then plot these values and create their first non-linear graph. In the picture (Fig. 2) there is another step where we put the data into the computer and work with it.

Pupils learn to read values from the graph, discuss the properties of the obtained curve, etc. At the end of the activity, the pupils explore the function of the pendulum in a mechanical clock and are often surprised to discover that the pendulum does not make the clock move as they had thought, but stops it, giving it the correct rhythm.

Fig. 1 Measuring in the classroom

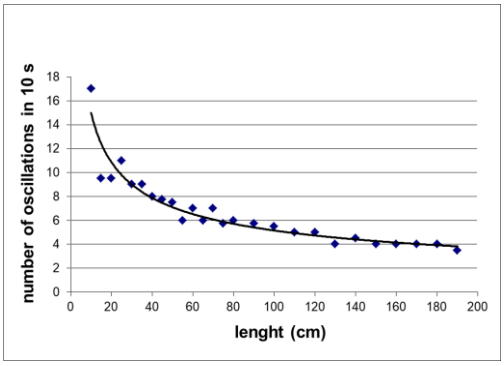

Fig. 2 Obtained data fitted with a curve

Reflection activity with students

Reflecting on the whole activity, the pupils describe in their own words the research cycle they have gone through in the previous lessons and realise what knowledge and skills they have acquired or started to acquire. They begin to understand that what is most important in this way of teaching physics is not the knowledge of physical phenomena, but the whole set of competencies they are learning (although of course, they do not describe it in these words, but in their own language).

Workshop programme at the conference

We have many years of experience with this activity – both in the classroom and with teachers at Heureka seminars. Workshop participants will go through a given topic unit just like the students – from the sundials to creating the graph and reflection activity at the student level. In addition, however, we will of course discuss the activity from the teachers' perspective, explaining why and how we do it in Heureka and what our experience with it has been.

In the workshop, we will also discuss our experiences of extending the activity into the upper years of lower or upper secondary school. The workshop will also include a discussion of our other experiences from working with pupils and students in the Heureka project.

Conclusions

Thanks to the fact that the participants of the workshop will try out the pendulum exploration themselves in the role of pupils, they will be able to directly transfer this activity into their teaching if they are interested and thus implement here inquiry base learning with their pupils.

References

[1] L. C. McDermott, M. L. Rosenquist and E. H. van Zee, Students difficulties in connecting graphs and physics: Examples from kinematics, *Am. J. Phys.* **55**(6) (1987).

[2] A. Stefanel, Graph in Physics Education: From Representation to Conceptual Understanding. In: Pospiech, G., *Mathematics in Physics Education.* Springer, Cham. 2019. https://doi.org/10.1007/978-3-030-04627-9_9

[3] I. Dvořáková, Active Learning in the Heureka Project - Teachers in the Role of Students, *Scientia in Educatione* **8** (2017) 42-58. doi: 10.14712/18047106.731