

Inquiry into Application of the Spreadsheet Model Experiments in Physics Education

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Abstract

Paper presents results of Spreadsheet Model Experiments creation and verification of their applicability at school praxis. The objects of research are models created in Microsoft Excel Spreadsheet environment – possibility of their usage at Secondary Grammar School Education.

The basis for work was an analysis of the Physics textbooks for Secondary Grammar Schools in Slovak Republic and a questionnaire with the view of Physics teachers at physical phenomena modeling, which brought us an inspiration for own models creation.

We verified created Excel Spreadsheet Model Experiments by small pedagogical research at some Secondary Grammar Schools. There were instructions for teachers and worksheets for students prepared as a part of the Spreadsheet Models performance.

Material types of models are mainly used in physics education at Slovak secondary schools at the present time. Graphs, drawings and schemas represent other commonly used types of models. Information and communication technologies (ICT) and teaching ICT provide some new ways of modeling in physics education. Computer programs are able to replace a difficult calculation and process vast bulk of data. Software proves a visualization of the frequently complicated mathematical formulas in physics. Spreadsheet program environment (for example Microsoft Excel in the Microsoft Office suite and Calc from the Open Office suite) is the one of the possible options to further the objectivities of modeling in physics education. Probably every personal computer has a spreadsheet program and therefore we have an easily available tool for the making and using of mathematical models. There are many spreadsheet programs in hand [5].

To prepare a set of spreadsheet model experiments from the selected parts of secondary grammar school physics in relation to the curricula and to verify these models in school praxis were our tasks.

1 Spreadsheet model experiments

From our point of view, *the spreadsheet (or quantitative) model experiment* (SME) is a mathematical model of the physics phenomenon made in a spreadsheet program environment. It follows instructions of the modeling: original – abstract model – mathematical model – design algorithm – computer program – model. The basis of a model is an equation or a system of equations. The variations of input parameters for the applied model equations modify output data such as a graph and/or numbers.

SME respects the principles of experiment preparation in physics education, too: to have a goal, demonstrativeness, color balance, correctness, appropriateness ...

In the process of a model construction the analysis of the secondary grammar school physics curriculum has been accomplished at first. The next steps were:

1. selection of suitable physics phenomena;
2. didactic goal setting of a model;
3. creating of a model in spreadsheet environment;
4. creating of a worksheet for students with the structure: a short theory of phenomena, directions for the model use, physics tasks for the student to work out individually;
5. creating an accompanying document for teachers with the structure: comprehensive curriculum, motivation, student knowledge requirements and purpose of the model, instructions for the use with a picture of the expected model environment, suggestions for application in the teaching process;
6. arrangement of conditions for using of the models in physics lessons;

7. verification of the model in the teaching process.

By using SME in physics education we expect to:

- reduce an amount of mathematical calculations, therefore a way to the core of physics phenomena is quicker;
- increase students' activity during and excluding the lessons;
- obtain a lot of interesting exercises;
- include the model in the parts of teaching process (motivation, explanation, exercise, fixation and assessment);
- enhance mathematical calculations with graphics.

2 Inquiry into application process

With our expectation we accomplished the pilot research of the application spreadsheet model experiments. The goals were to obtain feedback about prepared models and to get the teachers' and students' opinion on teaching with spreadsheet modeling:

- Do SME help students make sense of educational theme on the required level?
- Do students give priority to using models before the classical teaching method?
- Is working with the spreadsheets complicated?
- What is the opinion of teachers on application of SME as a mean of object teaching?

To collect the information we used an interview method, a questionnaire method and an observational method. Students worked with SME and the worksheets. After handing over the filled-in worksheets, students were given the questionnaire about models. This way we obtained the observations and ideas of possibilities of using computers and spreadsheet models in physics lessons. Teachers filled-in another questionnaire about modeling in their physics teaching.

This pilot project was done by 5 spreadsheet model experiments with 6 teachers and two groups of students at two grammar schools:

- Group 1: 23 students of regular third year class.
- Group 2: 20 students from first year class focused on mathematics and physics.

It was realized in a computer classroom. Maximum two students sat at one computer.

3 Research results

The student worksheet had multiple-choice questions, physics tasks with an unknown quantity and questions with an open answer. The final question was about student internal opinion on the model.

There is one example with the percentual results of Group 1 and Group 2 of correct answers for the spring oscillator model below.

Group 1: Tasks 1 and 2 were multiple-choice questions about the dependency of physics quantities. Tasks 3 and 4 were simple physics tasks with an unknown quantity. Students had problems with reading the graph, with the axis assignment of quantities. Task 5 was about damped oscillations.

Group 2 worked with models out of their school in our department.

Other tested spreadsheet model experiments were: Hydrostatic pressure, Body motion and friction, Electric potential of point charge and In-line superposition of harmonic oscillators.

Conclusion

We found out that students had been highly attracted by the spreadsheet model experiments – quantitative mathematical modeling in Excel – and they had considered the prepared models to be a suitable support for educational methods in physics. The students would also appreciate if more themes in physics were prepared by means of quantitative modeling. Computer was one of the motivating elements for them. On the other hand, some students had problems to read the graphs.

Spring oscillator SME

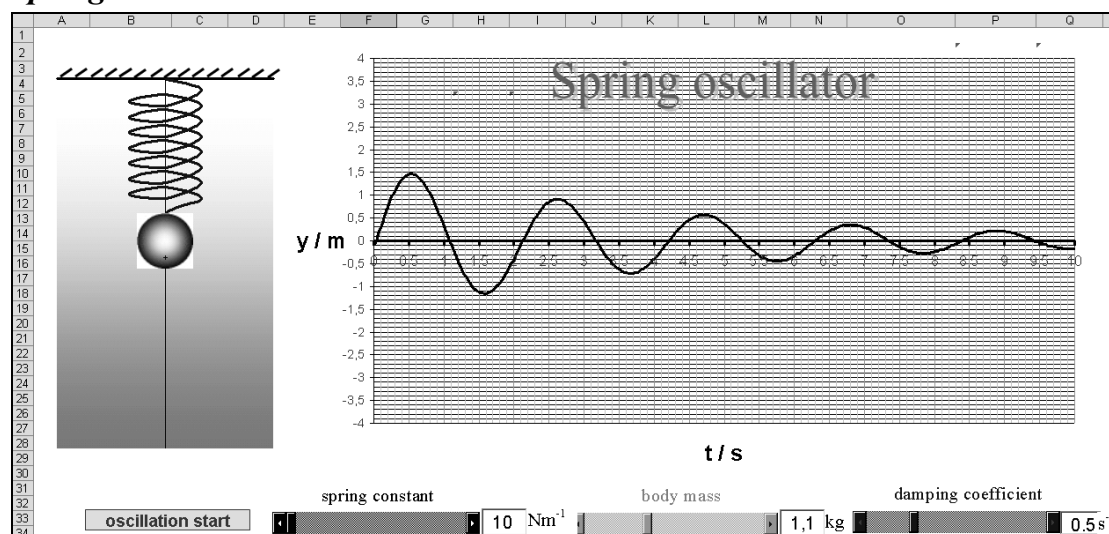


Fig. 1. Environment of spring oscillator spreadsheet model experiment.

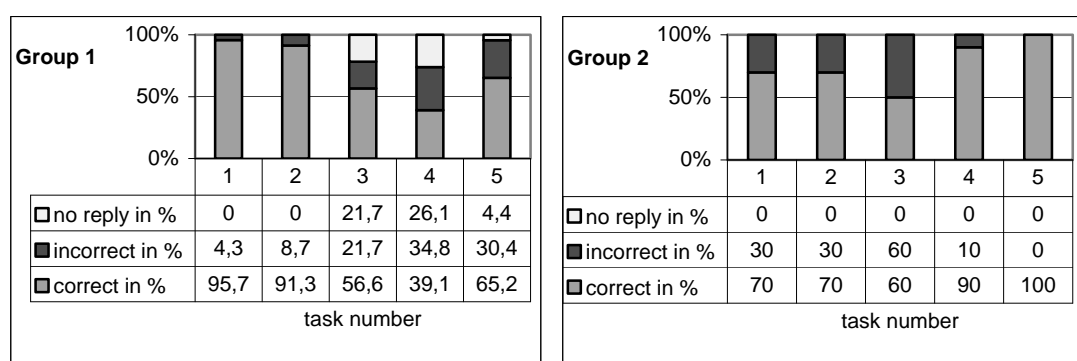


Fig. 2. Percentual results of correct answers for the spring oscillator spreadsheet model experiment for both Groups.

When asked, physics teachers appreciated the fact that models were very illustrative and helped the students understand the core of surveyed physical phenomena. A set of prepared spreadsheet model experiments means a significant contribution for teachers from the school praxis. It helps students understand complex physical topics and the prepared worksheets represent an appropriate instrument for their self-contained practical training, too.

But the connection of the spreadsheet model with a real-world phenomenon has a higher didactical value of the model experiment for the knowledge acquisition in physics education. And vice versa the real experiment is supplemented with a model, too. These ideas was applied in publications *Integrated Science through Experiments*, e.g. [2].

This approach is the one facet of the modeling – *Model Research* (Students investigate a specific area to gain a deeper understanding of some behavior and learn how to use what has already been created or discovered). The other two facets – *Model Analysis* and *Creative and Empirical Model Construction* – are the two steps to achieve the objective of modeling: Students investigate meaningful and practical real-life problems. [1]

In our opinion, this pilot research was successful and we will continue in this theme of physics education research. We have to do some structural changes of student worksheets and questionnaires, prepare other spreadsheet model experiments, prepare instructions for reading graphs and considerably enlarge a research group of students.

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