Empowering learning through dynamic modelling activities to enhance physics education

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Abstract. Inquiry-based science education emphasizes active learning where students, through inquiry, answer a research question applying a scientific method based on experimentation or modelling approach. Experimentation is a primary means of inquiry. Modelling, as another essential aspect of the inquiry approach, allows students to represent and manipulate abstract concepts, explore relationships between variables and make predictions about the system behaviour. In the workshop, the principles of dynamic modelling will be introduced. Participants will develop their own dynamic models within the COACH learning environment software. Through hands-on activities, they will get insight how to integrate dynamic modelling activities into their educational practices.

Introduction

Inquiry-based science education emphasizes active learning, where students engage in the process of scientific inquiry to explore concepts and phenomena. Through inquiry, students answer a research question applying a scientific method based on experimentation or modelling approach. Experimentation is a primary means of inquiry, when students pose questions, design and conduct investigations through experiments, and draw conclusions based on evidence. Modelling, as another essential aspect of the inquiry approach, allows students to represent and manipulate abstract concepts, explore relationships between variables and make predictions about the system behaviour. By integrating experimentation and modelling into learning students are provided with authentic opportunities to explore world around us.

Modelling in physics and science education

As defined by Hestenes [1] “a model is a surrogate object, a conceptual representation of a real thing. The models in physics are usually mathematical models, which is to say that physical properties are represented by quantitative variables in the models”. Blum and Leiss [2] described the process of modelling in a modelling cycle. Firstly, the question or problem has to be understood, simplified and translated into mathematics. When performing mathematical computations, a computer with suitable software can significantly help. In this phase, mathematical terms can be translated into a computer´s language. The results gained by computer have to be transformed back again into mathematical language when the results are applied and interpreted for the real situation (Figure 1).

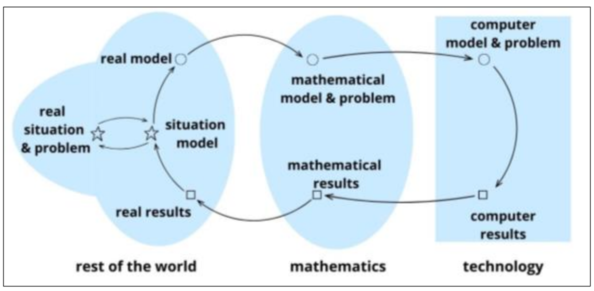


Figure 1. Modeling cycle by Blum and Leiss extended with the use of digital tools [3].

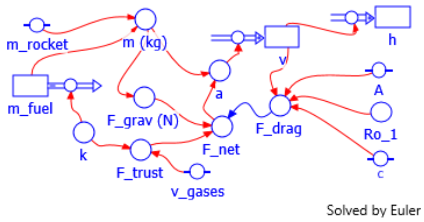
Modelling activities

Computer modelling can be integrated into existing physics and science curricula at various levels. We have designed a modelling path providing a structured progression for students to develop their modelling skills and understanding from simple models to more complex problems. When possible, the model is compared with the corresponding experimental data from the videomeasurement or real measurement.

Students develop computer models using numerical methods to approximate solutions and simulate the evolution of a system over time. The available computer software, such as COACH7 learning environment (http://cma-science.nl) enables to develop such dynamic models of phenomena in a text mode using mathematical equations or in an iconographical mode when the variables and the relationships between them are represented by graphic symbols (icons).

In the designed learning scenario the iconographical modelling is applied starting with the introduction into modelling where students learn the basic principles and the meaning of different icons in terms of different variables and relations between them. Each activity starts with the basic model and the level of complexity is added gradually. The designed learning scenario with examples of selected activities and models is presented in table 1.

Table 1. Example of activity from the modelling learning scenario

Activities with their subactivities	Example of a complex rocket model
Intro to modelling How force affects motion – Fall of a heavy/light ball – Fall of a sky diver How Felix achieved the speed of sound How rocket starts – Rocket in free space – Rocket in constant gravitational field – Rocket with drag force – Rocket with changing air density	

Conclusion

The iconographical modelling offers a possibility to model physics phenomena without using demanding mathematical equations that are often beyond the knowledge and skills of students in mathematics and physics. This way even more complex phenomena can be brought into the classroom and the corresponding models can be developed by breaking the process into simpler parts. Gradually introducing more complexity, students can build their understanding of real-life problems. Moreover, if possible, the developed model can be compared with the experimental data and its parameters can be manipulated to achieve the best correspondence. Incorporating modelling into physics education not only enhances students´ conceptual understanding and development of inquiry skills but it also enables to see the relevance of physics in the real world.

References

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