COMPUTER-AIDED MEASUREMENT AND SIMULATION USING LABCAMERA AND FIZIKA SOFTWARE IN PHYSICS EDUCATION

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ABSTRACT

Digital transformation of education is an inevitable and a clearly positive process. Use of computers in science education is particularly useful, as it opens new possibilities for teachers in knowledge transfer and experimentation as well as helps students gain deeper understanding of science problems. This paper will show how cutting-edge education technology can be used through a number of practical examples.

INTRODUCTION

All kids are natural born scientists. Even at the very early age of 2-3 years, children tend to be fascinated by the surrounding world. This instinctive curiosity towards natural science often fades away quickly after students start learning science subjects in school. The lack of time for experimenting in the classroom, abstract teaching methods, textbook-based science education often result in the loss of interest in science subjects among children.

LabCamera and Fizika software provide a funny, playful and engaging way for students to carry out substantial scientific exploration at home or in the classroom. Besides providing fun for students, these two software packages enable teachers to carry out spectacular, computer-aided classroom experiments using old instruments or by creating a simulation – this way avoiding the necessity of spending thousands of dollars on the newest data-logging devices [1].

When using these software packages in class, students often do the same experiments in small groups, sharing their results in a discussion session at the end. This way they are encouraged to think creatively, to share their ideas and to develop the art of teamwork.

LABCAMERA

In order to use LabCamera software, all is needed is a simple webcam. Any built-in or USB webcam can be used, there is no need for any special equipment. The software itself is a cross-platform application for Windows, Android and Chrome. LabCamera is a software that is easy to handle: teachers and students can start using it from day zero. In addition to this, it is possible to download a simple manual and over 50 lesson plans from the webpage of Intellisense Zrt [2]. If one is not skilful in carrying out experiments or simply time allowance is tight, it is possible to use pre-recorded videos for further analyzing.

In the following sections we will introduce shortly four of the seven different modules of the program to give an impression about the abundant possibilities the software provides and show how they can be used to improve science classes.

TIME LAPSE MODULE

The Time Lapse function helps students observe and understand better the slow processes in nature, such as the formation and migration of clouds, the growth of plants, etc. The software makes still shots and stitches these images into a coherent stream of video. This video can then be played back or further analyzed in other modules. Depending on the slowness of the observed process, the time interval between subsequent frames can be set to any value between 0.2 seconds and 24 hours.

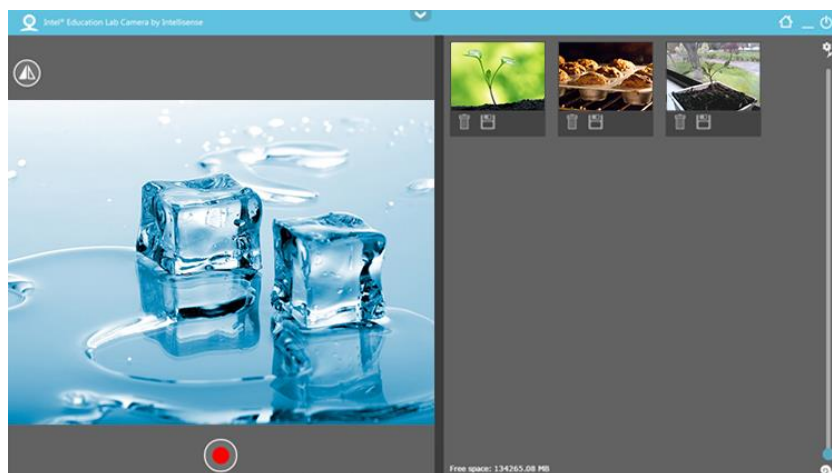A typical experiment that can be carried out using this module is the melting of ice cubes (see Fig.1).

Fig.1. Investigating the melting of ice cubes with Time Lapse module

In this experiment images should be captured in 1-2-second intervals. For basic level (primary school) students observing the process is enough fun, but for higher level students it is also possible to carry out different measurements using the recorded time lapse video. One such possibility is to measure the volume of the cube as a function of time.

KINEMATICS MODULE

This module - which offers probably the widest possibilities in carrying out physics experiments - is based on colour recognition. All one needs to do is place a colourful object in the field of view of a webcam and click on the object. This will make the program recognise its colour and follow its motion throughout its movement. The software is capable of capturing a maximum of 3 objects at the same time, allowing for complex kinematics experiments such as collision or coupled pendulums.

Once an object is recognised and followed by the program, selected graphs of the horizontal and vertical components of its motion (displacement, velocity, acceleration) will be displayed on the right of the screen in real time. Such a real time graph situation is shown in Fig.2.

Using the option to visualize more graphs (such as displacement-time and velocity-time graphs) at the same time, it is possible to give students ample experience on the connection between graphs. This helps students gain a better understanding of graphical representation and analyzing, which is one of the toughest parts of the physics syllabus in secondary school.
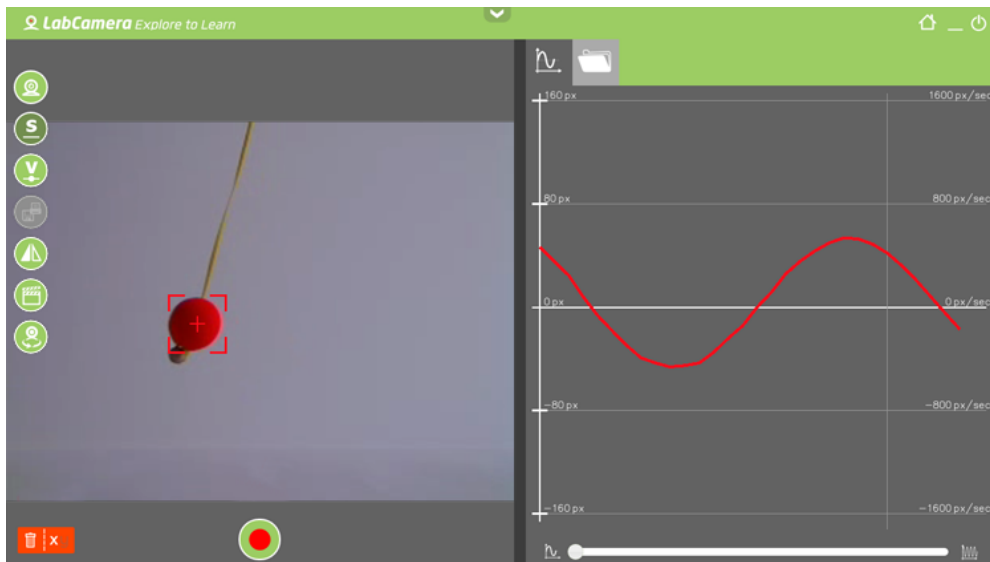
Fig.2. Real-time displacement-time graph of a pendulum, generated in the Kinematics module

A typically good experiment that can be done with this module is the investigation of the connection between uniform circular motion and simple harmonic motion (SHM). This experiment is shown in Fig.3. Since the program graphs the components of a motion, it can be shown quickly that the perpendicular projection of a uniform is an SHM. With higher level students it is also possible to check the formula for maximum velocity and acceleration in an SHM.
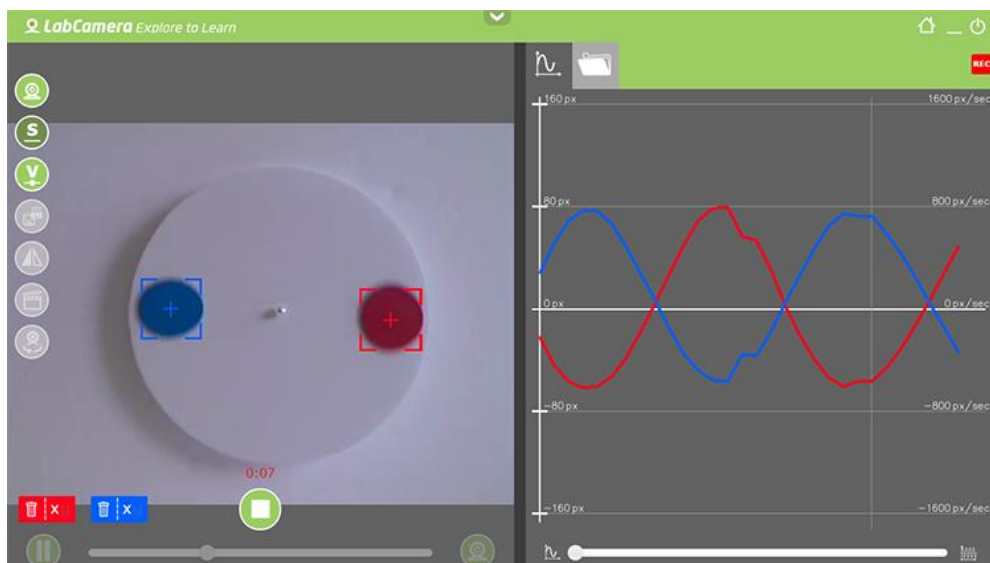

Fig.3. Investigating the components of a uniform circular motion with Kinematics module

A useful option in this module is that in the case of complex investigations, all recorded data can be saved in .csv format and analyzed later (possibly as homework).

There are also additional features, such as background elimination and trail visualization that make Kinematics module an ideal tool to use for observing and investigating various motions, ranging from oscillations to circular motion, collisions and free fall.

MICROSCOPE MODULE

With the help of Microscope module it is possible to explore objects ranging in size from microscopic to astronomic. For best results with this module, a manual focus macro enabled camera is recommended, since this will enable cell level measurement.

Built as a universal measuring tool, the Microscope module enables students to measure distances, angles and areas. Offering the option to load pictures or use a webcam to take a picture, Microscope module can be used to measure objects such as craters on the Moon, buildings, trees or much smaller objects such as sugar crystals, snowflakes or onion cells. Fig.4. shows such possible measurements.
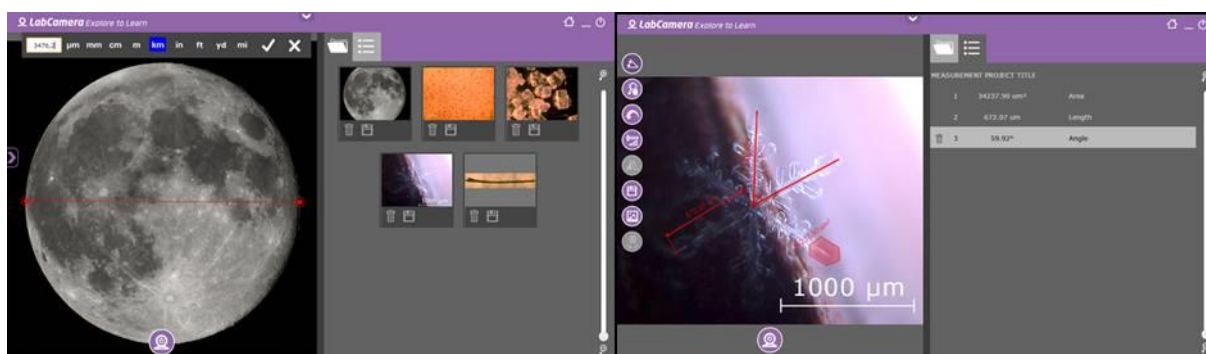

Fig.4. Measuring distances and angles on astronomical and microscopic objects using Microscope module

A typical experiment in physics that can be carried out using this tool is investigating Snell's law. A set of pictures can be loaded in and angles can be measured to collect sufficient data for verifying Snell's law or to measure the refractive index of a given material.

UNIVERSAL LOGGER MODULE

Universal Logger is a unique, real-time data recognition module that can register real-time readings of any instrument that has digital, dial or liquid-in-glass display. All the obsolete measurement devices in school that cannot be connected to a computer can be made useful again with the help of this module. Thus, by simply using this software, schools can save an immense amount of money that would be spent on data-loggers.

Typical instruments - from which data can be obtained - are digital multimeters, liquid-in-glass displays (such as thermometers or simple U-tubes for measuring pressure) and dial displays. The use of these types of instruments is shown below in Fig.5.

Fig.5. Instruments from which data can be logged into a computer with the help of Universal logger module

A typical experiment that can be carried out using this module is investigation of a battery. Once the digital multimeters that measure current and potential difference are calibrated in the program, it takes only 1 minute to carry out the experiment and collect sufficient data. Furthermore, since data can be saved and further manipulated, it takes a few further minutes to graph potential difference against current or power against resistance with a few clicks.

There are 3 more modules (Motion cam, Path finder and Graph challenge) that offer further possibilities in science education, but due to the lack of space we will leave it to the reader to explore those using the website of the software [3].

FIZIKA SOFTWARE

Fizika is a simulation program that models physical processes in an interactive way. It enables students to use preloaded objects or just draw on the screen to create scenes and experiments, then press the play button to get them in motion. One example of such a complex drawing is shown in Fig.6. In this case the consequence of travelling in a car without seatbelts on is illustrated. The wheels of cars are driven by engines and as the cars collide into the walls, the passenger without seatbelts will continue its motion and fly out of the car.
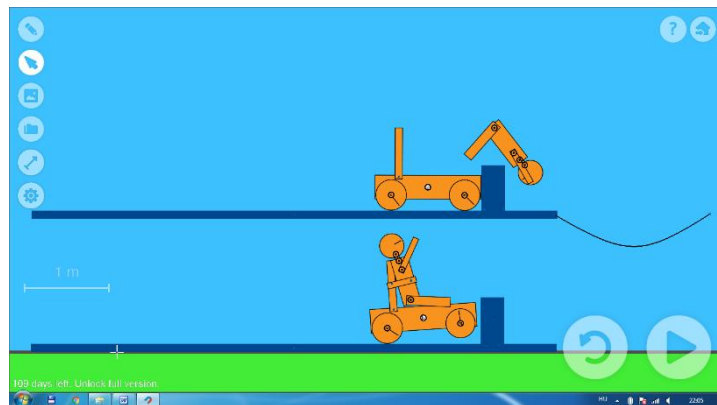

Fig.6. Simulation screen showing a collision with and without seatbelts on

Once a simulation is set up, it is possible to change the properties of the objects by just one click. This way a whole set of experiments can be carried out effortlessly.

Fizika (similarly to LabCamera) offers a real-time graphing option. If a marker is set on an object, it measures the motion of the given object (displacement, velocity, acceleration) and displays it in real-time.

It is possible to change between displacement-time, velocity-time and acceleration-time graphs with just one click, which provides a perfect opportunity for comparing and analyzing graphs. Furthermore, the data obtained in a given simulation can be saved in .csv format and can be analyzed later. Fig.7. shows a simulation screen with the graphs displayed in real time.

Another important feature of this software is that the reference system can be set to any stationary point or even onto a moving object. Fig.8. illustrates how the displacement-time graph changes if the reference system is set to one of the moving cars.
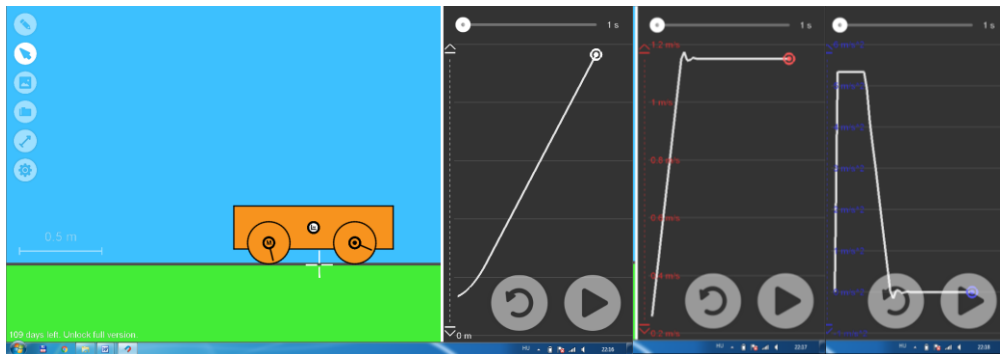
Fig.7. Simulation screen of Fizika. Distance-time, velocity-time and acceleration-time graphs are displayed in the case of a starting car
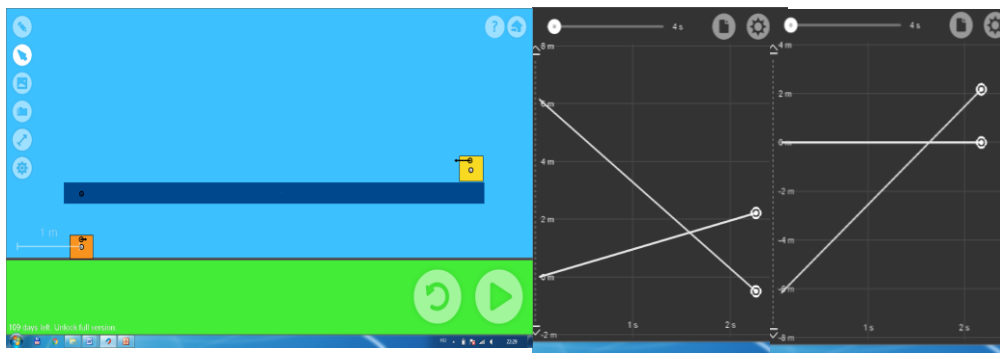

Fig.8. The effect of changing the reference system. The displacement-time graph on the left is measured from a stationary reference system, while the graph on the right is measured from a system fixed to the yellow box

Typical experiments that are recommended to be carried out using this software are the ones which are too complicated to set up in real life or the ones in which the effect of a parameter is investigated, but the parameter can not be easily changed in real life. A good example is the investigation of the effect of the coefficient of friction on the starting of a car.

Further details about this software can be found on the website of the program [4]. A study on the results of a teaching experiment investigating the effectiveness of using Fizika is also available on the website or in this volume [5]. Lesson plans for using Fizika can also be downloaded from "resources" [2].

THE IST PROGRAM

The "Intellisense for Science Teachers" Programme (IST) was called to life to build and support a community of passionate science teachers through creating, sharing exciting science education materials. It provides free software of LabCamera and Fizika for every science teacher in the world and also downloadable materials such as lesson plans and videos. We do encourage every physics teacher to sign up for a free copy and enjoy using these software.

REFERENCES

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5. T. Tóthné Juhász: A simulation-based teaching experiment, present volume