DATA LOGGING IN THE SCIENCE LABORATORY OR ANYWHERE ELSE

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ABSTRACT

In the past few years there has been a growth of interest in how computers can be best harnessed in order to improve the efficiency and effectiveness of education. The use of the ICT toolkit is restricted by the limited infrastructure and the attendant high costs of access (e.g. software, updating). Data logging is a central feature of practical activity in the modern science laboratory. In my study I discuss the vital parameters of data loggers, which must be considered in the case of shopping. I show how all the measuring activities may be readily performed using only a data logger. It is hoped that the experiments will make it easier for teachers to introduce data logging to students in a meaningful manner.

INTRODUCTION

With the sponsorship of the European Union, in many schools a professional science laboratory was developed. This is Öveges Programme. This programme provides the possibility for 10 elementary schools of the district of these labs to do natural science experiments as they are having lessons in the lab, too. With this renewal the schools received new IT equipment, for example data loggers which can be used for Physics, Chemistry and Biology as well.

We hope that this programme will go on and other schools will get the possibility to improve their toolkit. In this paper I give some practical advice to those who have the potential or chance to obtain IT tools. My work in this programme was to help schools in getting all the tools which they really need and want. I met the expectations of the teachers, and now I would like to share my experiences.

THE COSTS OF DATA LOGGERS

We all know what the situation is between students and Science classes, so we have to reach an improvement in student attitude towards science. Modern apparatus in the lab offering many new and exciting features is a good possibility to reach this aim [1].

Nevertheless, our financial possibilities are limited. There are many types available on the market. Everybody wants to get professional and cheap tools. Based on resources, the first characteristic of these items that we usually check is the price. In some cases this amount does not contain the price of the software. The cost is raised a lot if the software and the updates must be paid separately.

Another financial problem can occur if we have to buy a PC to run the software of the logger. It is useful to choose a cost saving product with a built-in computer and rechargeable battery. This solution is cheaper, and you can also use these portable data loggers for out-of-school experiments, or you can smuggle them for Science in class trips [2]. Fig.1. shows a class trip experiment conducted in a forest. Humidity, temperature, light intensity and air

pressure were measured while the students were walking on a path farther and farther from the highway. Before the trip they were asked to decide which four parameters to check. They carried out the experiment using only a data logger. They also made notes with the device during the process, so no paper sheets or pencils were needed. If the graphing and analysis tools normally only found on the PC are built in, we really can get a stand-alone data logger and analysis tool.

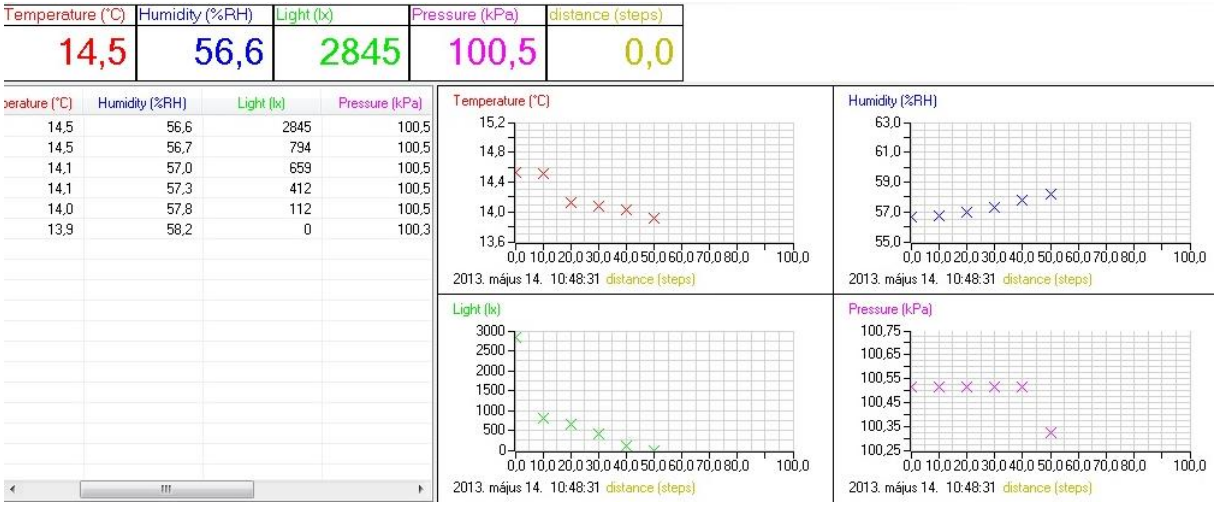


Fig.1. Abiotic factors measured in a forest

Incidental malfunctions, damages and warranty should also be mentioned. The chosen product must be resistant to the shock, percussion, overload or impact caused by the users. The connection lead or the plugs are used to be a critical point. In turn, generally we don't have to worry about computer viruses. Basically the software of the loggers are programmed in their own system, they are not threatened by Windows or Mac viruses.

LEARNING PROCESS

Besides the cost of the new apparatus, educational aspect shall also be concerned thoroughly. Teachers are overloaded, but the weekly number of the science sessions is so low, so we have to get as much as possible into those hours. Teachers' work can be grouped into 3 parts. First, the preparation before the lessons (planning, setting up the experiments), then managing the students' work during the lessons, and thirdly the evaluation (homework, practical work, tests). The logger is expected to help the teacher in this total work. How is it possible?

To be able to use a new item, some learning and practice must be performed. The simpler the platform and the software, the easier it is to learn the operation. Simple menu also supports the students in their work. However, it can be scary for the children if they see a lot of icons on the screen, the device must be able to carry out many different data collecting and analysing processes, as you can see in Fig.2.

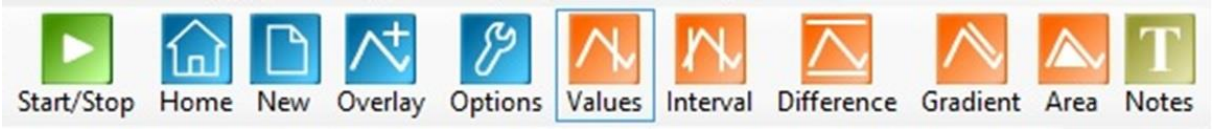


Fig.2. Icons on the screen for quick data analysis

It is preferred if we can choose from different levels of the software, offering different expanded possibilities, according to the age and preparedness of the students.

ATTRACTIVE PROPERTIES MAKING LIFE EASIER

The first meeting of the pupils with a tool determines their attitude towards the device. Students use their smart phones continuously. Fig.3. indicates an item having its own fully coloured high resolution LCD touch screen, similar to tablets and smartphones, which helps us to bring the students into a familiar relationship with the tool.

Fig.3. A logger with a touch screen

The best for students is if they can do the experiments themselves, but in many cases the teacher's demonstration is needed. It's a benefit if it can be connected to a projector or monitor. This is absolutely relevant, required whenever the teacher needs to present a demonstration or introduce an experiment to a class, even to provide training on how to use the device.

To get on well with Science is a hard work for the students, we could make it easier if they can carry out their experiments in their own language. The possibility to choose an alternative language is a helping hand for the teacher, too. Also a detailed user's manual must be enclosed in the mother tongue of the teacher. Furthermore, there should be teaching materials and booklets with experiments developed especially for the given device. In some cases, loggers are supplied with built-in setup files matching these documents.

Teachers would like to carry out hundreds of experiments with their logger, it's important to choose a manifold type, with many sensors, which can be built-in, or which we can buy separately. To decide what sensors to buy, collect some information on the available ones from the manufacturer or the distributor, and have a discussion with your Biology, Chemistry, Geography colleagues. Teachers don't have to bother with the calibration of the sensors, if it is done by the manufacturer. The sensors should also have a built-in protection against overloading.

COLLECTING AND ANALYSING DATA

Measuring activities may be readily performed using a data logger, so students can record their captured data in a table and plot the results on a graph quickly. It's interesting to examine a live graph, for example the increasing of CO_2 level in the classroom during a lesson. Or we can leave the operating logger in the classroom for some days, and measure the changes of the light level and the temperature with the variation of day and night.

If we are talking about long-term remote data logging, then we should mention processes which are too quick to observe with human sensory organs. A professional logger is able to manage short measuring time with a small intersample time, at a range of some microseconds. Fast data logging is necessary for Physics, and is also used in Biology, in checking pulse or

heart rate, for example. Fig.4. shows how the current changes in a light bulb after it is switched on. The measurement time is 200 ms.

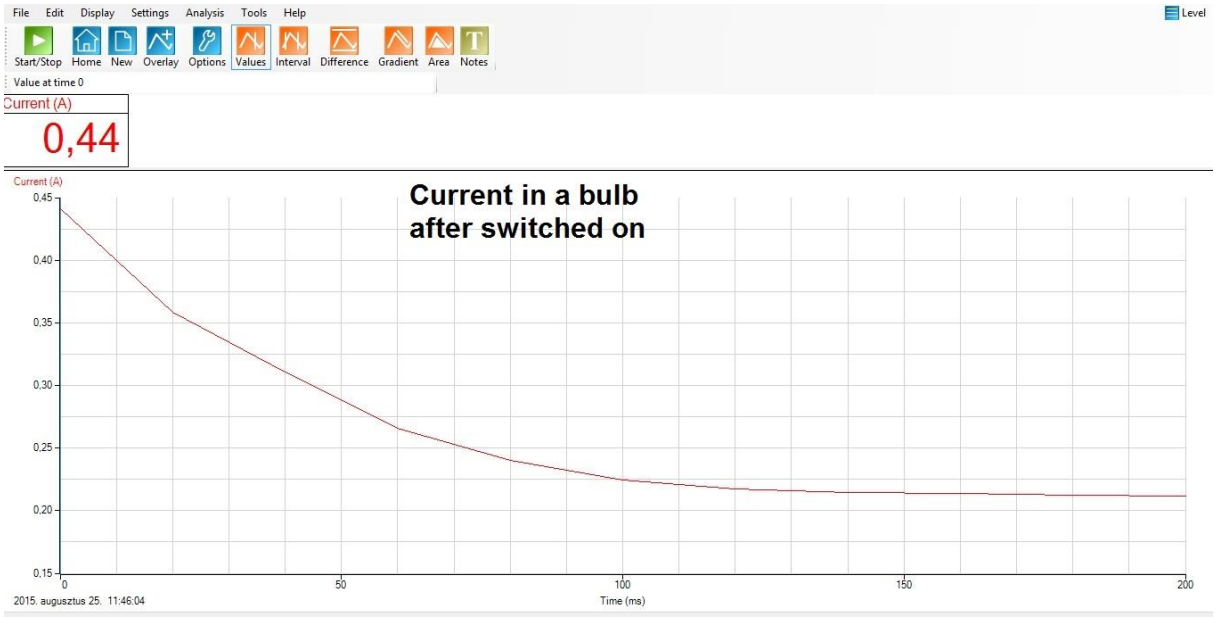
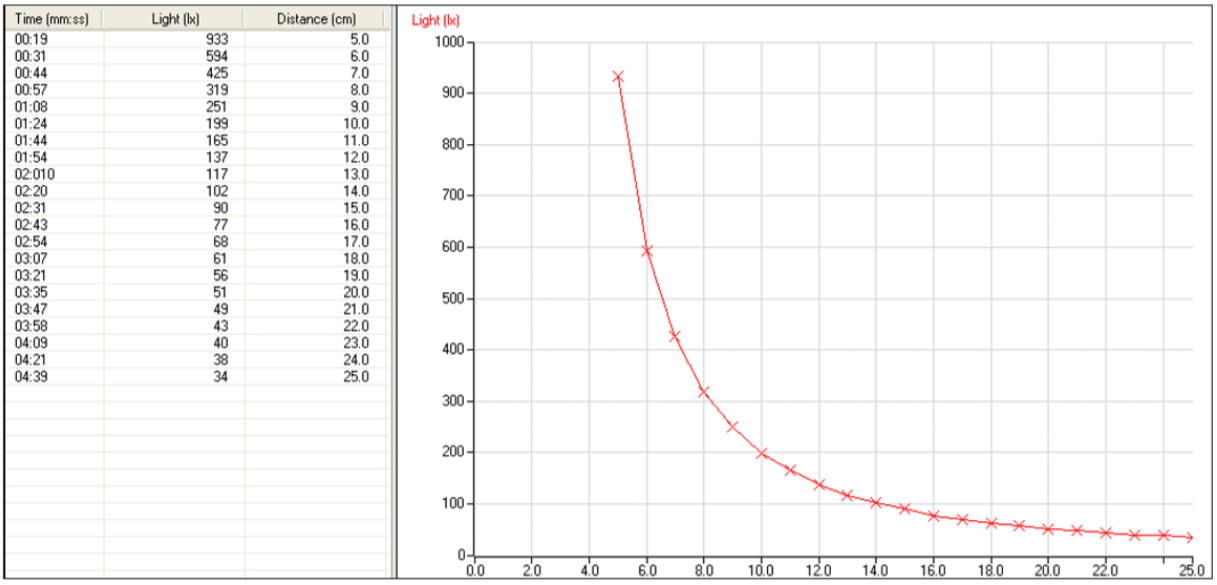


Fig.4. Current falls according to the increasing resistance [3]

Besides data collection, we also need the possibility to analyse the graph plotted from the captured data. Related to the type of the experiment, we plot our data as the function of each other, or simply as the function of time. So we need an x-axis that can be changed according to our expectations.

Different processes are observed with different methods. Our logger must be able to meter and plot discrete and continuous data. For example, let's check how the light intensity changes with the distance from the light source. To get data, we position the light sensor against a ruler so that we can measure the distance from the light bulb to the Light Sensor. With this process we get a discrete graph. The fitted curve indicates the inverse square law. Results are shown in Fig.5.



Time (mm:ss)	Light (lx)	Distance (cm)
00:19	933	5.0
00:31	594	6.0
00:44	425	7.0
00:57	319	8.0
01:08	251	9.0
01:24	199	10.0
01:44	165	11.0
01:54	137	12.0
02:010	117	13.0
02:20	102	14.0
02:31	90	15.0
02:43	77	16.0
02:54	68	17.0
03:07	61	18.0
03:21	56	19.0
03:35	51	20.0
03:47	49	21.0
03:58	43	22.0
04:09	40	23.0
04:21	38	24.0
04:39	34	25.0

Fig.5. Light intensity as the function of distance from the light source

To see the correlation between the different variables many transformations need to be applied. For example, if the change of the pressure of a gas is measured with the change of the volume of the container, it is not enough to plot the p(V) graph. To get the well-known Boyle's law data is treated to produce a 1/V or a 1/p plot, which gives a straight line. With the function wizard we can display that the volume of gas is inversely proportional to the pressure (provided that the mass and the temperature remain constant).

If we do the transformations in Excel, we have to plot the new columns again and again, which is a waste of time. With a logger the required graph appears after only a few clicks. Of course, there is the possibility to save each graph before the transformations, title them and make notes at the same time, without any sheets of paper or a computer, using only the data logger.

It is not a dream to have enough tools for the class. Each measuring pair should use a data logger, carry out the experiment and do the analysis parallel with the others. And when they are ready, they just connect the logger to a printer and have the final graphs printed. In this way the teacher can easily check the overall work of the students in only one step, and the pupils can glue the graph into their writing pads.

STUDENT WORK AT HOME

Basically a normal class is 45 minutes long. It is almost impossible to carry out the experiment and do the total analysis process in this short time. Having a multiuser PC software included in the price is also a benefit that provides students with a wide range of PC-like functionality. This way the logger can still be used with a PC when required. Students can take their measurements at home, they can analyse, work on their own PCs with a software which looks and behaves just like the stand-alone one. It is also essential to have the possibility to save data in xls format, so pupils can easily export data into a spreadsheet. In this way, homework can also be solved.

CONCLUSIONS

- With a professional logger we can collect and analyse data quickly and easily. The price of the tool and the software are important so many factors and aspects must be considered.
- All in all stand-alone loggers are cheaper because no PCs must be bought for the operation.
- When we start to use a new equipment, it is beneficial to have a software with optional languages and user's guide in every individual's mother tongue. After all, maybe worksheets should be provided too.
- There is quite a wide range of variables which should be measured in a science class. The more sensors are available, the more experiments can be done with the chosen device.
- Multiuser software running on the kids own PCs is a good point, giving also the possibility to do their pieces of homework.
- There is no need for any calibration or setup, simply choose a type which is already calibrated and able to do automatic setup.
- With a complete measuring system, we get accurate and real-time data, it allows long-term studies and quick measuring. In addition, it provides portability and options for homework. All these things result in students good at science and satisfied teachers.

ACKNOWLEDGMENTS

This project is a result of my work in Öveges Programme, with which many school laboratories have been supplied with data loggers. It gives me immense pleasure to prepare this report on the expectations and experiences of the teachers involved in the programme.

I would like to thank Almus Pater Ltd. for providing me an opportunity to use the equipment, loggers and sensors offered for testing and demonstrating. I sincerely thank my students for their contribution to the student experiments. I wish to express my sincere gratitude to the Graduate School for Physics of ELTE University and its Partners for the possibility to share my thoughts with the international Science teacher community that participated in the conference titled Teaching Physics Innovatively.

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