

INNOVATIVE FORM OF LEARNING PHYSICS IN ENGINEERING STUDY PROGRAMS

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Abstract: This research paper demonstrates the use of experimental problem based learning tasks which students of computer science and information technology study programs realized through a semester in physics study course. In this course students had to master how to use several sensors and how to connect them to Arduino and acquire proper measurements and save them in a memory card. Students admit that in most of the experiments using Arduino as a data logger gives advantages to more easily deal with experimentation. Students appreciate that this kind of mastering physics is more related to their specialty and future work. It becomes more significant to use measuring devices not only in laboratories but also in different environments where specific data acquisition systems are necessary. Therefore with this teaching method students realize the real life needs and conditions.

Keywords: PROBLEM BASED LEARNING, SENSORS, ARDUINO, DATA LOGGING, LABORATORY WORKS, PHYSICS

1. Introduction

To engineering students physics has to be taught differently than with classic methods of teaching. Physics in fact is basis of every further research and study so it must be taught properly and adapted to specific study programs. Based on research and observations technology instructions in physics should make scientific views more accessible and meaningful. The main goal is that technology should be used in teaching and learning of science as one of learning possibilities and not to have less effective results than other learning styles [12].

Problem based learning (PBL) is known as highly effective type of learning and is by far considered as one of the best methods in education. Especially combined with specified technologies that can be used with commonly known sensors and measuring methods. Most commonly known appropriate reasons when studies are provided by technology are: a) to use computer interfacing equipment to collect and process data of a measurement or experiment; b) to perform experimental or theoretical modelling and to use computer simulations; c) to use research and presentation programs for gathering and displaying information [4].

Common interfacing devices, which are used in the study process, are probes that are plugged into graphing calculators or measuring interfaces that are usually connected to computers. With aid of these devices students are capable of collecting and analyzing data of several measurements [9].

Usually all measurements in physics in Liepaja University are realized with aid of measuring interface Cobra3 – basic unit, provided by PHYWE. A lot of measurements can be taken with this interface, but there exist certain problems, that prevent students from using it. To use the interface in specific experiments a special measuring module has to be used which has to be purchased and does not come in the original packaging. Another considerable fact is that using the original packaging experimentation cannot be done in places where there is no electricity.

In year 2015 from September to December computer science and information technology students studied physics course using experimental PBL and microcontroller Arduino to solve complex problems. These students had previous knowledge about electrical components and Arduino programming basics.

Adapting classic physics course in the interest of computer science and information technology students is definitely a challenge to deal with.

2. Materials and connections

A wide range of microcontrollers are available in the market. Because of the price and other available parts and sensors Arduino

was chosen over others offers. The Arduino is open source, which means hardware is reasonably priced and development software is free. The Arduino platform consists of a set of microcontrollers, a programming language and an integrated development environment. The language is based on the Wiring and Processing languages, which were created to teach core programming and computing concepts through electronics and visual arts respectively to nonprogrammers. With the Arduino board, you can write programs and create interface circuits to read switches and other sensors and to control motors and lights. The Arduino language is syntactically similar to C and its platform has wide-spread open source community support, numerous projects, and is easy to use. The challenge from a teaching perspective is to bring all this hardware and software into a cohesive platform for computer science pedagogy. An important feature of the Arduino is that user can create a control program on the computer, download it to the Arduino and it will run automatically. For stand-alone operation, the board can be powered by a 9 volt battery for example [8].

There are countless examples of Arduino being used to log weather conditions, atmospheric conditions from weather balloons, building entry data, electrical loads in buildings, and much more. Because of the small size, low power consumption, and ease of interfacing with a lot of sensors, Arduino is a considerable choice for building data logger, which is a device that records and stores information over a period of time. Data logging systems are very simple. They generally consist of some kind of acquisition system, such as analog sensors, to obtain data. They also contain some kind of memory for storing data over a long period of time [10].

A large number of sensors are available to monitor and measure many types of environmental parameters or physical processes. The rapid advances and usage of programmable microcontrollers have brought an increase in the availability and ease of use of sensing physical phenomena. The sensors operate on low voltage [11].

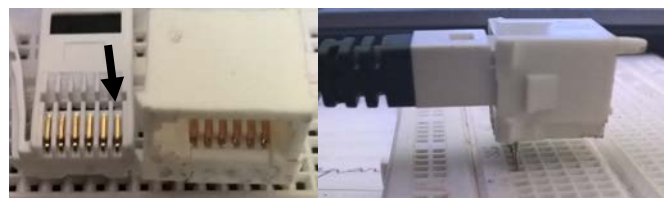


Fig. 1 BTA male and female connectors (from left side). First pin of the male BTA connector is marked with black arrow.

Most of the sensors that students had to use were provided by Texas Instruments that were used before with interface Coach Lab II. All of these sensors have British telecom analog/digital connectors (BTA/D) according to sensor. Connectors have six pins and their usage depends on the sensor that is used (Fig. 1). Vernier provides protoboard adapters which can be used when connecting sensors and other necessary equipment for measurements to breadboard. Breadboard connections for students were taught before

in other courses. Students used simple BTA/D connectors with necessary resistors for each sensor (Fig. 1).

For connection of Arduino and Vernier sensors students used universal connection principles (Table 1) which can be fitted for specific sensor because not all of them use all six pins (for example Fig. 2). For all occasions connector can be connected to the Arduino in such a manner. But in most cases Vernier sensors especially analog sensors use only three pins and they don't need the others to operate properly.

Table 1: Sensor and Arduino connections.

Number of connectors	Pin	BTA to Arduino	BTD to Arduino
1		Pin A1	Pin 2
2		Pin GND	Pin 3
3		Pin A4	Pin 4
4		Pin A5	Pin 5V
5		Pin 5V	Pin GND
6		Pin A0	Pin 5

One of the most important things in physics is capability to measure voltage because in most of experiments which includes electricity this kind of measurement is important. Arduino analog inputs can be used to measure direct current voltage up to 5 volts therefore for higher voltage measurements a simple voltage divider is necessary. The analog sensor on the Arduino board senses the voltage on the analog pin and converts it into digital format that can be processed by the microcontroller. For voltage measurements students used simple sensor from Texas instruments. Experimental setup is shown (Fig. 2).

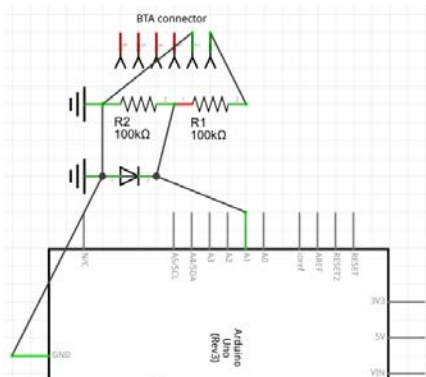


Fig. 2 Voltage sensor connection to Arduino.

Each sensor has to be connected to the Arduino in a proper way to avoid failures and acquire reliable results. Therefore with each sensor connection a schematic description is given (Fig. 2 and Fig. 3). In most experiments only the basic electronic components are used. Even students with lower level of knowledge have almost no problems in dealing with schematic representations.

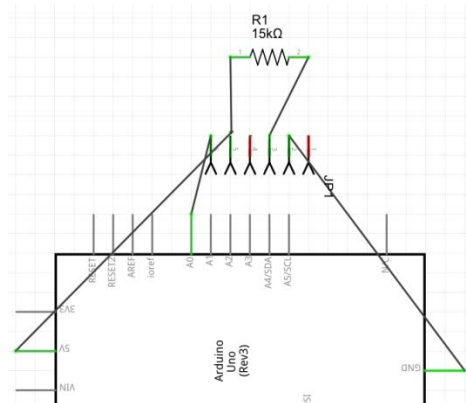


Fig. 3 Temperature sensor connection to Arduino.

Arduino has limited storage therefore memory cards must be used to store all the measured data. Data can be retrieved offline when data taking is over. Data can be stored in text files. That kind of information is very easy to process and deal with because it is

commonly known and often used format. In fact using memory card it is easier to process and visualize the acquired data afterwards.

Before using SD card it has to be prepared. Most SD cards are already properly formatted and are ready to use with an Arduino. Formatting SD card doesn't require any specific skills. SD cards can be connected to Arduino via official shield or other simple memory card modules (Fig. 4) [13].



Fig. 4 Memory card module.

Fritzing is a software application that is used to create schematic representations of hardware connections (see examples Fig. 2 and Fig. 3). Fritzing can also be used as a tool in teaching electronics to people without an engineering knowledge. Therefore students make their own representation of laboratory works [7].

3. Laboratory procedures

In the semester students completed six laboratory works (uniformly accelerated motion, use of Newton's laws, circular motion and centrifugal force, specific heat of solutions, floating materials and conditions) that included using different sensors and Arduino as a data logger. Sixth laboratory work is described more in further section to introduce how these works are being done and what are the procedures and problems that students have to deal with during these work sessions.

Students were introduced to a certain problem with batteries. They had to investigate DC source which is made of aluminum plate and steel rod and as an electrolyte salt water is used (Fig. 5). And to get higher voltage and power a pipe cleaning fluid (NaOH) is used. As the dosage of cleaning fluid is increased the more hydrogen produces.

Students decided themselves what are they going to examine. Several students chose to explore how the produced voltage of this battery is dependent of the size of aluminum and steel materials. Others tried to examine the voltage dependency of pipe cleaning fluid used in the water. A few students saw that temperature also increases when voltage increases because of the increased amount of pipe cleaning fluid. Other students tried to explore this construction more as a battery. So they measured voltage, calculated internal resistance, connected this battery to a load (resistor) and measured current, calculated power and measured lifetime of this battery.

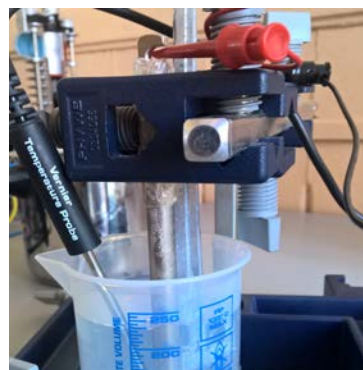


Fig. 5 Experimental setup of DC battery.

These experiments were quite interesting to students' especially when they had a chance to explore the same laboratory work with different methods of measuring. In the beginning they measured all physical quantities with a multimeter, chronometer and ethanol thermometer. After they measured necessary quantities Arduino and

sensors were given. As it was mentioned these students know at least programming basics. Sample programs of each sensors, SD card and timer were given but the working program they had to create by themselves.

Working at the second part of work students realized the necessity of data loggers. They could leave the data logger alone when the measuring process took a longer time. The measured data was easily processed afterwards through graphs and tables.

4. Results and discussion

Advantage of using experimental PBL is that students feel responsible for providing answers to the problems provided in the laboratory instructions, and those they encounter themselves. They develop skills to solve these problems, and therefore become more competent. Also laboratory time is used efficiently, with all participants fully engaged in the learning process. Students leave the lab more mature and confident about their skills. They know they can solve other problems when they encounter them in other classes or later in industry. Students develop understanding of how data acquisition system works and develop their own skills to solve hardware and software problems [2]. They also learn data acquisition techniques and software applications to solve real world problems.

Disadvantage is that students may initially struggle with PBL when this approach is new to them. They may not be prepared to answer questions posed by the instructor, they may want the instructor to solve all problems for them. Students may struggle with software and hardware for data acquisition. Learning how to use new software in one lecture can be a challenge also laboratory assignment may not be completed during the given time.

Data acquisition systems are used for laboratory research and are necessary more frequently in scientific research fields that are developing in Liepaja University. Data acquisition systems are interfaces between the real world of physical parameters, which are analog, and the artificial world of digital computation and control [3].

Many data acquisition systems are used in scientific application to acquire data and transfer it directly to computer memory. Data acquisition boards are general-purpose instruments that are well suited for measuring voltage or current signals or resistance that can include some form of signal conditioning [4].

Data acquisition and control system consist of sensors which measure physical variables such as temperature, pressure force, motion, voltage and current, signal conditioning, to convert the sensor outputs into signals readable in the PC. Analog input board, to convert these signals into digital format usable by the PC [6].

Capabilities and the accuracy of data acquisition systems can be founded from analog input specifications. Basic specifications are number of channels, sampling rate, resolution, and input range. Usually there is necessary a computer with appropriate application software to process, analyze and display data [5].

Student results were higher than previous years. Through these laboratory works they got deeper understanding about physical processes and how computer science is based on physical principles.

5. Conclusions

Different teaching strategies can be used to provide suitable education support to enhance the effectiveness of learning. Technologies are often used by teachers to improve teaching and learning process.

Data acquisition systems have always been used in education to measure physical phenomena [1]. Therefore the right choice of data acquisition system is critical. Due to the development of informatics, microelectronics and mechatronics there can be

observed a revolution in mechanics and measuring methods and technologies.

It becomes more significant to use measuring devices not only in laboratories but also in different environments where specific data acquisition systems are necessary. The Arduino platform is suitable for data logging and is considered very easy to use in physics and programming. Arduino can be used for many different purposes. This kind of studies demonstrate usefulness of automated measurements, and offer guidance for other researchers in developing inexpensive sensing and monitoring systems to do other researches [11].

5. References

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