THE APPLICATION OF AUTOMATICALLY CONTROLLED EXPERIMENT FOR INTERDISCIPLINARY STUDENT MOTIVATION

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Abstract. *The article analyses the application of automatically controlled physics laboratory experiment using information technology to enhance students' motivation and interdisciplinary communication. The paper reveals how the application of interdisciplinary methods promotes students' interest in studies, enhances the learning process and the quality of the students' learning results from the very beginning of learning process. It was practically justified that during the fundamental science laboratory experiments, the first-year students realistically assess their future career prospects. Students become aware of the perspective of the further studies because they work with equipment designed by higher courses students. As a practical illustration of the authors and students of physics experiment designed automated equipment. The experiment system realized combines mechatronics, electronics, and programming technical areas corresponding to students' professional specialization. The system of physics laboratory experiment, has attracted particular interest students and the author conviction increased student motivation to learn.*
Keywords: interdisciplinary motivation, automated experiment.

Introduction

The aim of the specialty education is to train qualified specialists who understand the principles of operation of various devices, measuring instruments and devices, can manage them, can explain complex production processes, offer and implement innovative proposals. The profiling of the subjects taught and the interdisciplinary training apply to this task. The use of traditional and non-traditional teaching methods increases the level of logical thinking and activity of students during lectures. Interdisciplinary relationships allow you to maximize the content of common subjects in subjects used in future practice (Debnath, 2005).

Interdisciplinary connection in the learning process provides the following advantages:

- Improves the learning process, affects the quality of knowledge acquired by students;
- Stimulates student activity, assimilating new material and demonstrates practical application;
- Develop educational interests and broaden the horizons of students;
- Promotes student creativity.

Interdisciplinary relationships not only increases the level of students' knowledge, but also contributes to logical thinking, the ability to analyse and distinguish the main subjects, explore new theoretical material and apply their knowledge in further practice.

Interdisciplinary relationships are realized by combining the first-year core subjects (mathematics, physics) with the subjects taught in the later subjects.

Motivation for interdisciplinary learning is realized through integrated lectures, practical experiments, general interdisciplinary links and additional technical applications.

The article presents a system of laboratory experiments in physics implementing three different fields of specialty (see Figure 1).
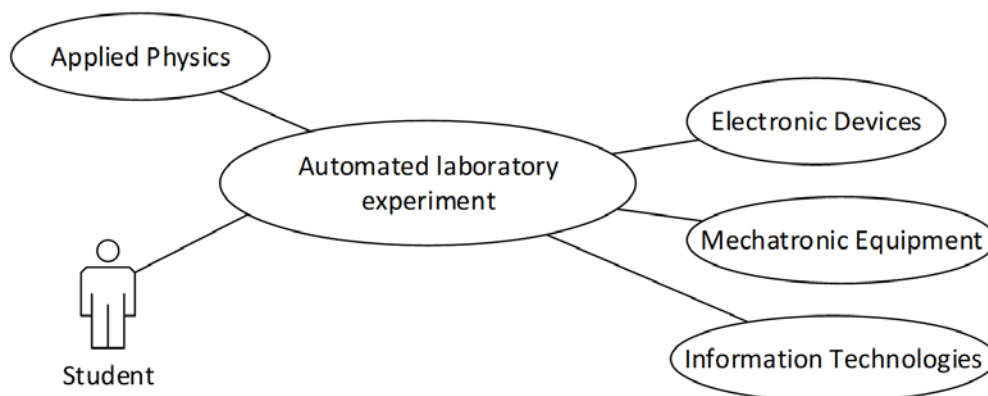

*Figure 1 **Interdisciplinary relationships are demonstrated through an automated experiment***

In this way, during the course of physics, the student gets acquainted with the subjects of electronics, mechatronics and informatics, which will be taught in later courses.

Realization of educational experimental System

Applying modern information technology, all computer-based experiments are conducted on a similar methods and have a similar architecture that can be

considered typical for microprocessor control tools with National Instruments LabVIEW software.

At the Physics Laboratory slider out an experimental laboratory experiment based on information technology. Figure 2 illustrates an automated experiment. An activity chart is provided.
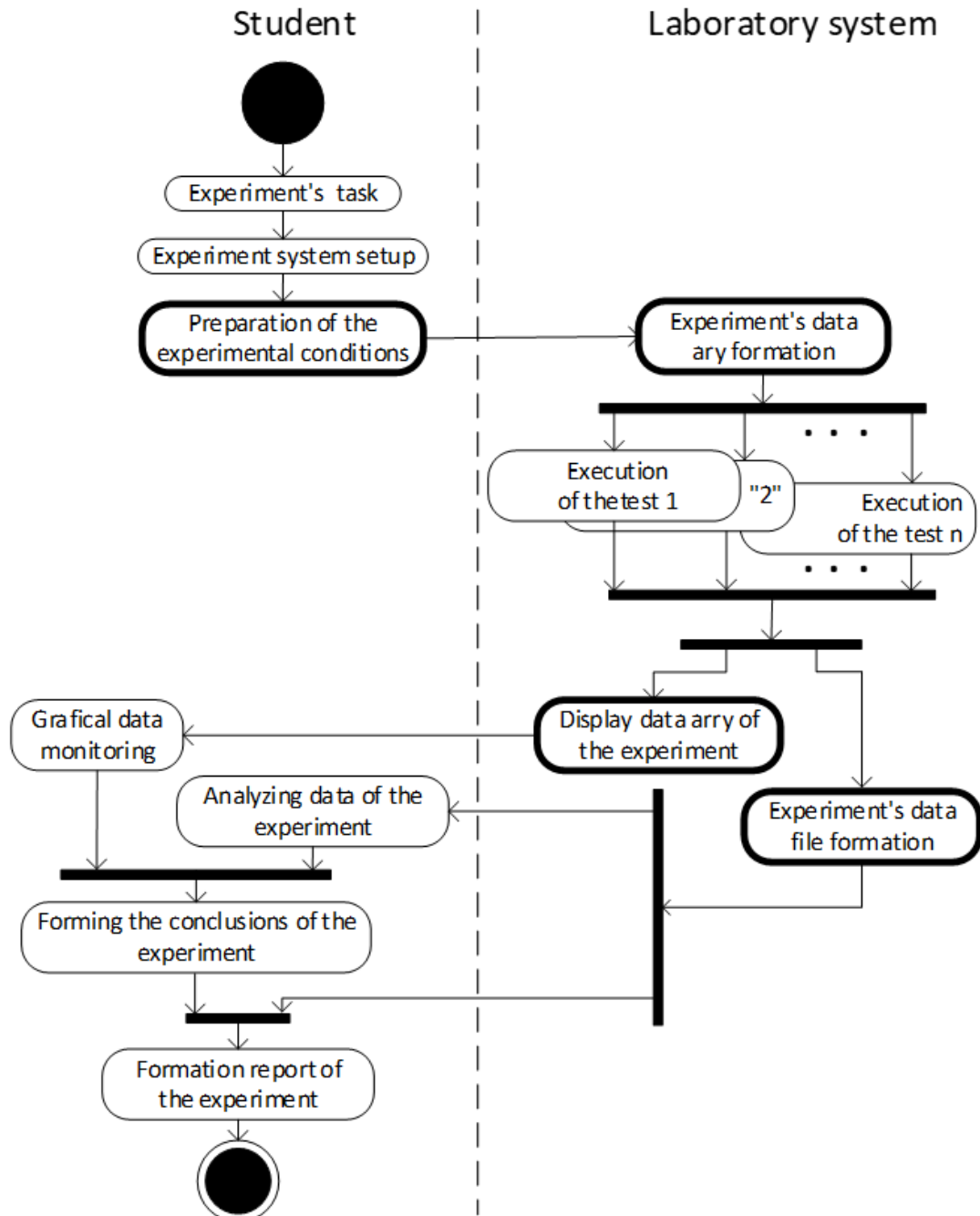

*Figure 2 **The activity diagram of Laboratory Experiment***

The following key actors are involved in the research experiment: an experimental student - (student) and an automated research system - (experimental system).

In the case of an automated experiment (Fig. 2), the student receives the task of the experiment and determine the conditions of the experiment and configuring the hardware and software to perform specific measurements. The automated system forms the test conditions, which are divided into groups of tasks for separate measurements. An automated system slider out a research group that may have a large number of defined tests: 1, 2, ... n. From such a complex research group, a data array is obtained whose graphical representation is displayed in the user interface. The same data is used to generate a result data file that is passed to the student. The student uses a text data file for further analysing of the results and preparation of the report. Conclusions are formed by comparing graph families, as many experiments are performed during the experiment.

The Equipment of the Laboratory Experiments is a complex mechatronic system contains hardware and software. Figure 3 shows the scheme of the system structure.
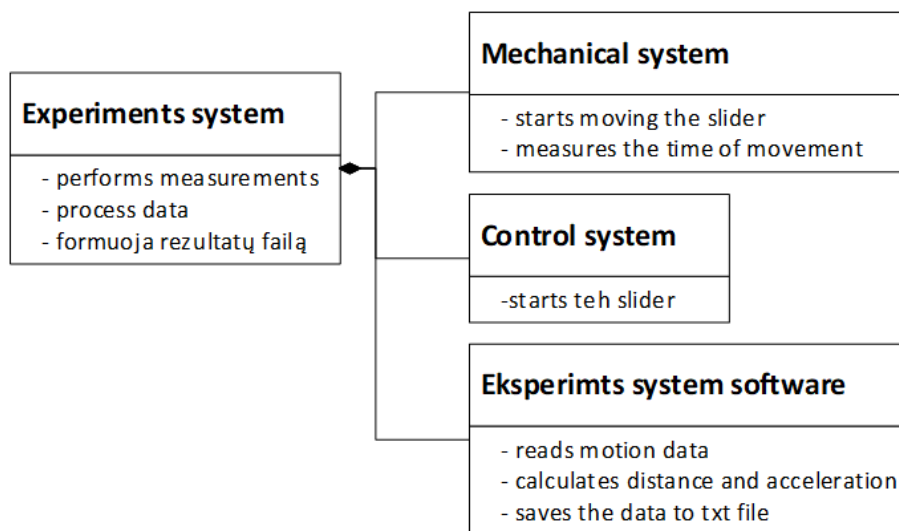
Experiments system

- performs measurements
- process data
- formuoja rezultatų failą

Mechanical system

- starts moving the slider
- measures the time of movement

Control system

- starts teh slider

Eksperimts system software

- reads motion data
- calculates distance and acceleration
- saves the data to txt file

Figure 3 **The structure of experiment system**

The overall view and components of the mechanical system are shown in Figure 4. (PHYWE, 2016).

The main part of the test apparatus consists of a hollow rectangular tube with airflow from the compressor (a) to facilitate movement of the slider (e). For stabilizing the slider force, a small weight (h) is used with a thread attached to the slider holder and passing through a wheel (g) with a motion sensor. The weight of the slider can be changed using special weights (d) that are mounted on the top.

The mechanical control system is designed to run the wheelchair and synchronize its movement with data recording (PHYWE, 2016).
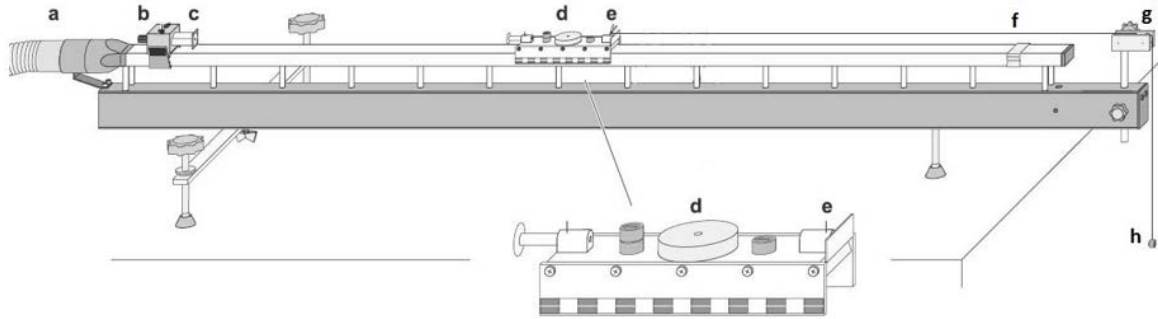
a - airflow supply from the compressor, b - the core of the electromagnet, c - the electromagnet who holds a slider, d – 100g weight, e - the slider with the bracket, f - the brake ribbon, g - the wheel with the optical sensor, h - the test weight .

Figure 4 **Linear motion test mechanical system** *(PHYWE, 2016)*

The structure of the experimental system software is illustrated in Figure 5.
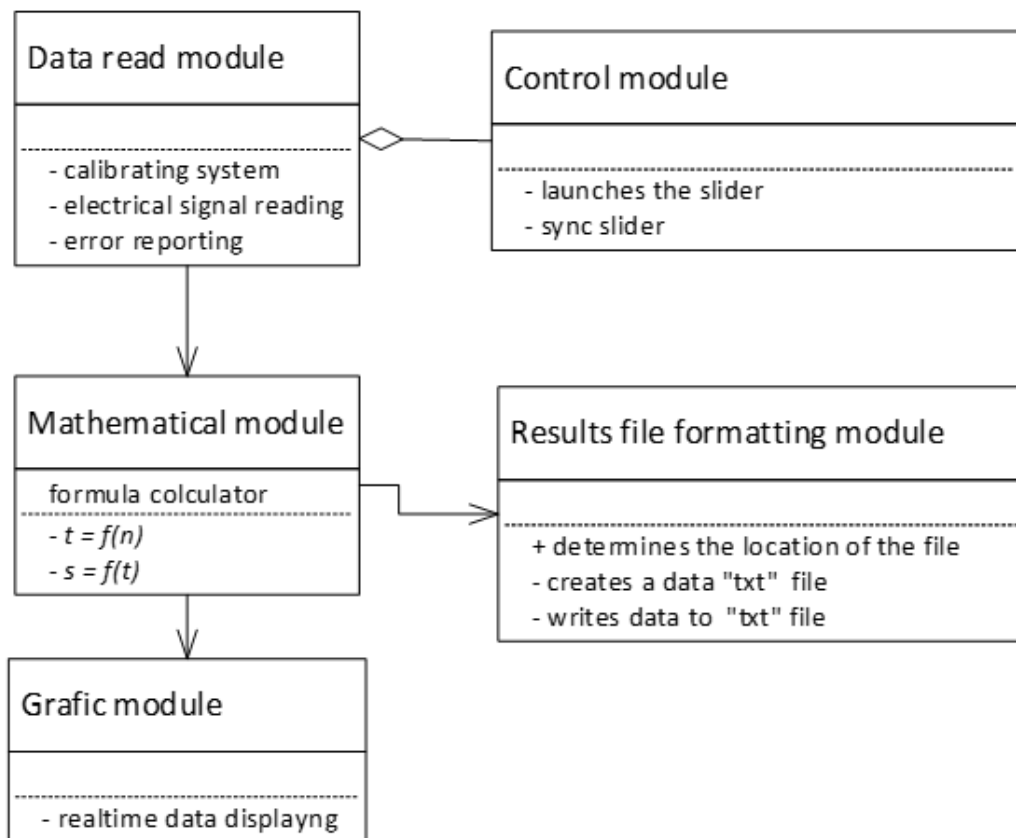

Figure 5 **Experimental system software class diagram**

The data read module designed to retrieve data from a mechanical part sensor and convert it into a form understood by a computer system. Control module designed to automatically control slider startup and is an integral part of the data reading system. The mathematical module contains mathematical functions needed to calculate the time interval *t* and the distance *s*. The graphic module represents the speed of movement. The result file formatting module saves the calculated information as data array of discrete values of measurement results.

Experimental software developed by LabView and running on a personal computer (National Instruments Corporation, 2009).

Example of Physics Laboratory Experiment

In physical experiments, linear motion is most often studied. The concepts of distance, displacement, speed and acceleration are used to describe this motion. The linear motion can be of two types: uniform linear motion and non-uniform linear motion with variable velocity or non-zero acceleration. The equations of kinematics for an object moving along the *x* axis with uniform acceleration *a* (constant in magnitude and direction) are:

$$\vec{v} = \vec{v_0} + \vec{a}t \tag{1}$$

$$\vec{s} = \vec{v_0}t + \frac{\vec{a}t^2}{2}. \tag{2}$$

Those expressions enable us to determine an object's velocity (1) and position (2) at any time in terms of the initial velocity and the acceleration. These relationships can be demonstrated graphically. The gradient of a line on a displacement time graph represents the velocity. The gradient of the velocity time graph gives the acceleration while the area under the velocity time graph gives the displacement. The area under an acceleration time graph gives the change in velocity. To help with this discussion of the signs of velocity and acceleration, we can relate the acceleration of an object to the force exerted on the object. In use a Newton's second law of motions we establish that force is proportional to acceleration:

$$\vec{a} = \frac{\vec{F}}{m}, \tag{3}$$

where: *a* - acceleration, *F* - acting force, *m* - mass.

In the experiment, the uniformly accelerated motion of a slider on an inclined linear air track is studied. At the lower end of the air track the slider is reflected by a massive block. (see Figure 6). The total mass of the slider is easy to vary by adding masses. Using these tools, you can determine how the net force on the cart, its mass, and its acceleration are related.

When the slider moves, the thread turns a circle with 40 four-millimeter-sized flat holes. Walkway signals are obtained using an infrared optical pair. The received signal, via the standard audio subsystem, enters the computer. Data is collected and processed on a personal computer using software specifically designed for this experiment. The data reading user interface window is shown in Figure 7. The measurement results are recorded in a text file in txt format that is compatible with most data analysis applications. The data is automatically documented with the possibility of further processing, and the progress of the study can be monitored in real time by the student.

The auto-start system, specially designed for this work, consists of an Arduino microcontroller module with software in it (Durfee, 2011).

Figure 8 shows the main window of the slider control program. Slider Launcher communicates with the Arduino microcontroller via the USB interface that controls the electromagnet (see Figure 4c) (Petry et al., 2016; Organtini, 2018).
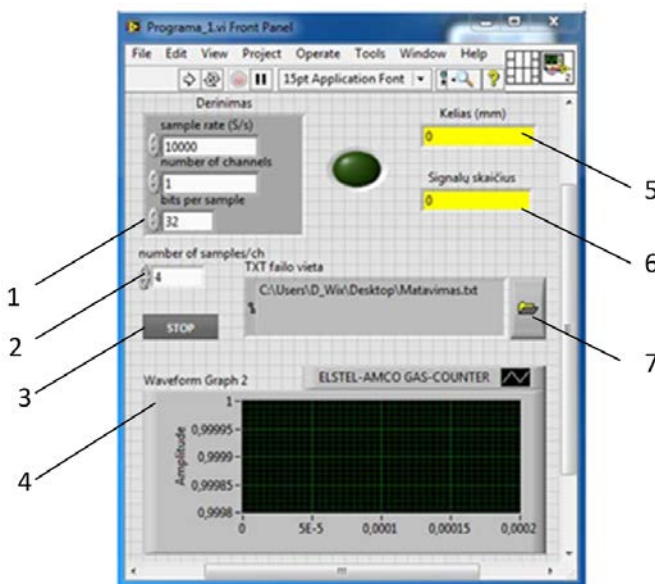
*Figure 6 **Data output software settings user interface:** 1 – settings, 2 – number of samples, 3 – manual stop bottom, 4 – waveform graph window, 5 – distance at time, 6 – quantity of measuring signals, 7 – the path to saving txt file.*
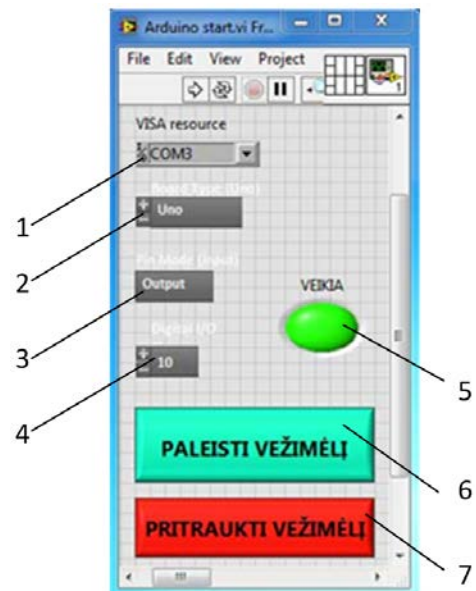
*Figure 7 **The main slider's control window:** 1,2, communication settings 3 – data output settings, 4 – number of measurements, 5 – measuring process indicator, 6 – slider start bottom, 7 – slider stop bottom.*

The slider starts moving and the motion data is scanned by the computer software running on the computer. The software stops when the slider goes to the end of the track. The data is saved in text file. The student can repeat several measurements using different masses.
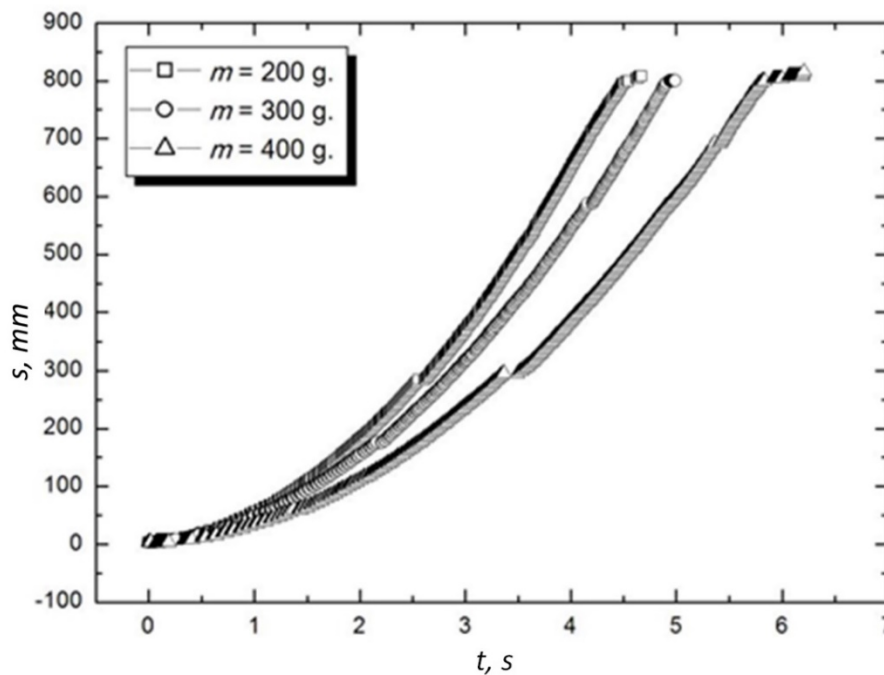
Figure 9 **Graphical Comparative Expression of Results of Laboratory Experiment II**
Newton Law Study

The results are displayed as a function of the time dependence of the track on a different slider masses.

Further experimental results are processed with mathematical data processing applications. In a particular case, the student can use the Origin software. A computer application represents the entire motion of the slider as a path-time diagram and makes possible further evaluation of the measured values. In particular, computation of the velocity and of the acceleration can be activated with a mouse click. The resulting graphical expression of the experiment results is shown in Figure 9. Three different masses ($m = 200$g, $m = 300$g and $m = 400$g) in one diagram, processed with the „Origin" mathematical application (Originlab, 2018). shows in Fig. 12. According to the graphical information, the student draws conclusions about the body movements of different masses, linking it with the theoretical knowledge gained during the lectures (Mandelis, 2018).

Interdisciplinary relations and student motivation

In the first year, students of many specialties have a practical exercise in physics, and therefore it is worth to raise students' motivation and interest in further studies from the first year. The author of the above-mentioned laboratory experiment system is a third-year student.

The Laboratory experiment system designed by student and implemented ir learning process, demonstrates not only the interdisciplinary links between

mechatronics, electronics and programming, but also encourages students rely on their abilities. In Figure 10 presented UserCase diagram illustrates the interdisciplinary connections implemented by a particular laboratory experiment system.
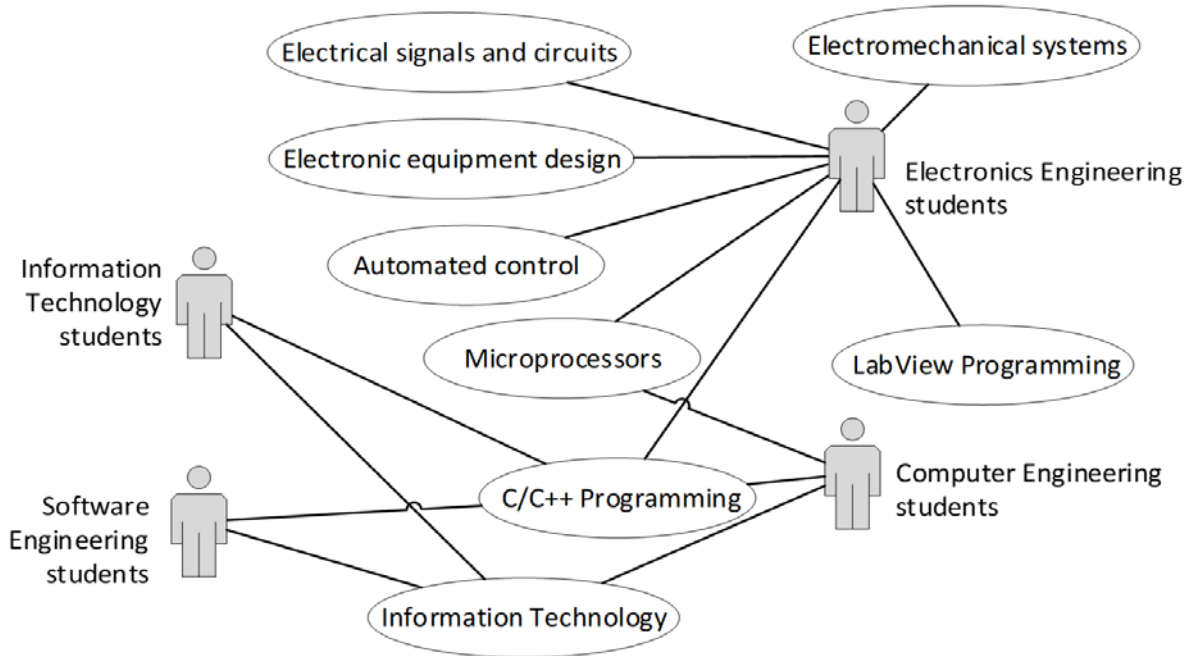

Figure 10 ***Interdisciplinary links with the laboratory experiment system***

Since the experimental system implemented in the physics laboratory is developed by the learner student, it motivates the students for further studies and builds their self-confidence. Experience from practical classes with first-year students shows that six interested students from Computer Engineering and Electronics Engineering specialities not only continued to study but also showed excellent results in individual subjects. Therefore, that means that the practically illustrated method of students motivation is effective.

Conclusions

The following conclusions can be made from the analysis of the application of the automated physics laboratory experiment developed by the students:

- Motivation of students for further studies is encouraged by the fact that students are able to see the applicability and possibilities of their specialty in the first year.

- As the automated experimental management system is designed for higher course students, it encourages first-year students to gain more self-confidence and improves the quality of their knowledge.
- During first year the student actually sees the practical benefits of the individual subjects studied. A student interested in the study process has less reasons to quit studying.

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