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OBTAINING FUNCTIONS FROM FOURIER SERIES WITH MATLAB

UDK: 517.5:004.434MATLAB
Original Research

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Abstract - Fourier series represent a very important tool for solving problems in any field of science that uses sinusoidal signals, such as engineering, physics, applied mathematics, and chemistry. So, good understanding of Fourier series is crucial for the process of learning the basics of these scientific fields. The theory of these series is complicated but their application is simple. Matlab as program package is suitable for easily plotting trigonometric series and the most convenient way for understanding their characteristics. In this paper we present a program written in Matlab that plot partial sums of three trigonometric series, as a way of finding periodic functions that series represent. We also give a mathematical proof for obtaining one of periodic functions that corresponds with our graphical representation.

Keywords: Fourier series, Matlab, periodic functions

I. INTRODUCTION

Mathematics is important to the extent to which it support and contributes to the purposes of general education [1]. Mathematical skills are crucial for a wide array of analytical, technological, scientific, security and economic applications. Mathematics forms the basis of most scientific and industrial research and development. Increasingly, many complex systems and structures in the modern world can only be understood using mathematics and much of the design and control of high-technology systems depends on mathematical inputs and outputs [2].

Mathematics is of central importance to modern society. All its need to be done is to understand the logic hidden behind. Mathematical calculations give way to analyze results of every experiment, and can help to make precise conclusions [3].

Fourier analysis is a way of mathematics analysis that has many applications in different scientific fields like physics, engineering, microwave circuit analysis, control theory, optical measurements and also in chemistry [4] [10].

The study of Fourier series is a branch of Fourier analysis. Fourier series were introduced by Joseph Fourier (1768–1830) for the purpose of solving the heat equation in a metal plate. The Fourier series and methods of numerically approximating it have been active areas of research since then [4] [5] [6].

Fourier series are used to approximate complex functions in many different parts of science and math. They are helpful in their ability to imitate many different types of waves: x-ray, heat, light, and sound. Fourier series are used in many cases to analyze and interpret a function which would otherwise be hard to decode and understand. These series has many applications in electrical engineering, vibration analysis, acoustics, optics, signal processing, image processing, quantum mechanics, and econometrics [5] [10].

In this paper we give a brief introduction to the Fourier series as a base of different scientific fields, we present a way of plotting the series in Matlab which can be helpful for their better understanding and studying. From mathematical point of view this presentation of trigonometric series with Matlab can be helpful for easily obtaining functions from given trigonometric series, which can be more difficult problem than the reversed one i.e. obtaining Fourier series from a given function.

II. FUNDAMENTALS OF FOURIER SERIES

In mathematics, a Fourier series decomposes any periodic function or periodic signal into the sum of a set of simple oscillating functions, namely sines and cosines. In other words, Fourier series can be used to express a function in terms of the frequencies (harmonics) it is composed of [5].

In engineering and technical sciences many practical problems gave periodic functions which are usually complex. We know that the function is periodic if it is defined for each real number x , and if there is a positive number T , called a period of $f(x)$ i.e. $f(x+T) = f(x), \forall x$ and the smallest period $T > 0$ named fundamental period of the function, according to [6] [7].

For simplicity and easier operation by periodic functions, we presented them with elementary periodic functions such as sine and cosine function who have a fundamental period 2π . This presentation of periodic functions like trigonometric series leads to Fourier series. Fourier series are very important practical tool because they allow the solution of ordinary (ODEs) and partial differential equations and they are also more practical than development of functions in Taylor (Maclaurin) series.

The particular conditions that a function $f(x)$ must fulfill in order that it may be expanded as a Fourier series are known as the Dirichlet conditions, and can be summarized by the following points:

1. the function must be periodic;
2. it must be single-valued and continuous, except possibly at a finite number of finite discontinuities;
3. it must have only a finite number of maxima and minima within one periodic;
4. the integral over one period of $|f(x)|$ must converge.

Therefore, Fourier series of function $y = f(x)$ is defined as follows: If $y = f(x)$ is periodic and integrable function of the interval $[-\pi, \pi]$, could be expressed as the sum of a trigonometrical series of the above form

$$a_0 = \frac{1}{2\pi} \int_{-\pi}^{\pi} f(x) dx \quad (0),$$

$$a_n = \frac{1}{\pi} \int_{-\pi}^{\pi} f(x) \cos nx dx \quad (1),$$

$$b_n = \frac{1}{\pi} \int_{-\pi}^{\pi} f(x) \sin nx dx \quad (2)$$

for each positive integer n .

A trigonometric series of the form

$$a_0 + \sum_{n=1}^{+\infty} (a_n \cos nx + b_n \sin nx) \quad (3)$$

with coefficients a_0 , a_n and b_n given by the integrals (0), (1) and (2) is referred to the Fourier series of the function $f(x)$ [6] [7].

That is the way for obtaining Fourier's series from periodic functions $f(x)$ of period 2π . The reverse way is more complicated and that is the reason way we used Matlab for plotting trigonometric series of n terms to obtain a periodic functions they derived from. For good understanding of Fourier series is essential to know both ways.

III. GRAPHICAL REPRESENTATION OF FOURIER SERIES WITH MATLAB

We are using three partial sums as example to show how a periodic function can be obtained from partial sum when n is big enough to recognize a function. To demonstrate plotting of Fourier series with

$$\frac{1}{3}\pi^2 - 4(\cos x - \frac{1}{4}\cos 2x + \frac{1}{9}\cos 3x - \frac{1}{16}\cos 4x + \dots) \quad (4)$$

Matlab we will use these three partial sums:

$$\frac{4}{\pi}(\sin x + \frac{1}{3}\sin 2x + \frac{1}{5}\sin 5x + \frac{1}{7}\sin 7x + \dots) \quad (5)$$

$$2(\sin x - \frac{1}{2}\sin 2x + \frac{1}{3}\sin 3x - \frac{1}{4}\sin 4x + \dots) \quad (6)$$

By their graphical presentation we will try to find periodic function that these series represent. First, we will present all three sums together in the same graphic for different n, and then we will plot separately in different graphs in order to obtain a clear view.

For plotting all three partial sums given in (4), (5) and (6) we are using this simple code written in Matlab.

```
x=linspace(-pi,pi,1000);
partial_sum1=0;
partial_sum2=0;
partial_sum3=1/3*pi.^2;

grid on;hold on;
axis([-pi pi -4 10])

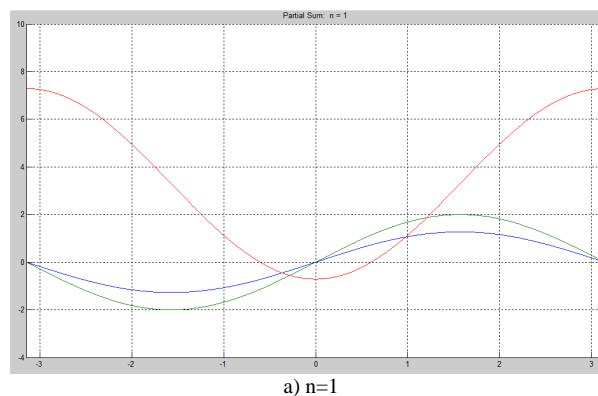
for n=1:1:100

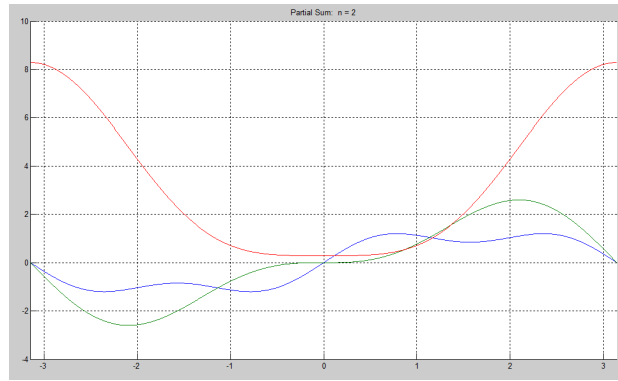
partial_sum1=partial_sum1+(4/((2*n-1)*pi))*sin((2*n-1)*x);
partial_sum2=partial_sum2-2/n*(-1).^n*sin(n*x);    partial_sum3=partial_sum3+(4/n.^2*cos(n*x))*(-1).^n;
    handle1=plot(x,partial_sum1,x,partial_sum2,x,partial_sum3);

    title(['Partial Sum: n = ',num2str(n)])
    pause
    set(handle1,'Visible','off');

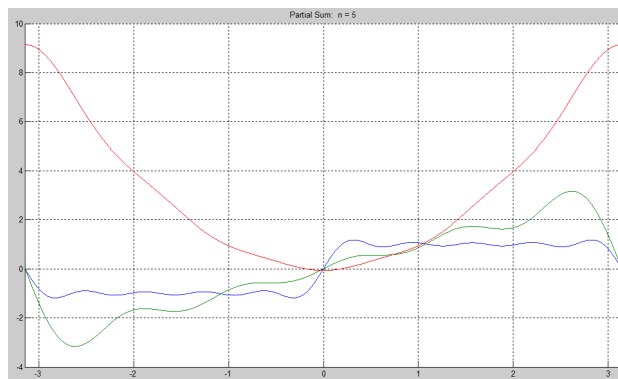
end
```

According to given code we first plot partial sums in period from $-\pi$ to π , and terms n are from 1 to 100. We present partial sums for different terms. Partial sums for terms of 1, 2, 5, 21 and 100 are given in Figure 1, a), b), c), d), e).

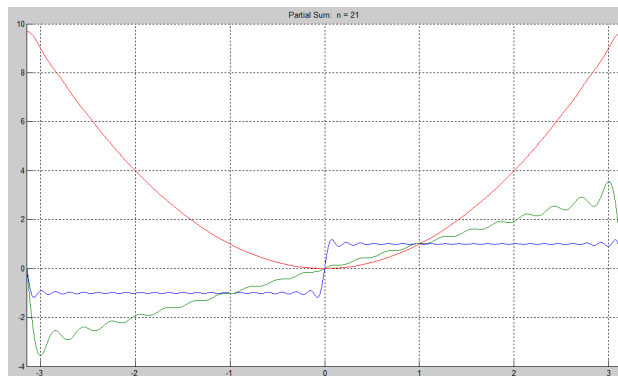




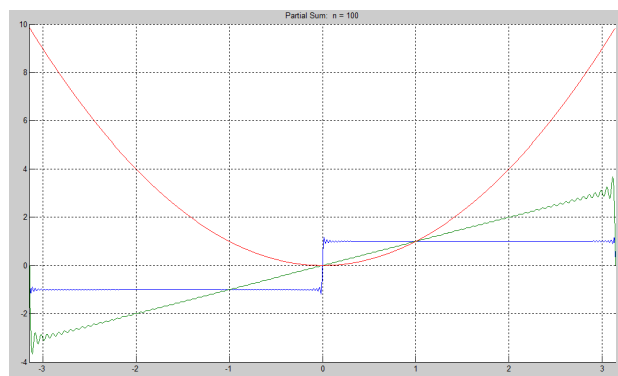
b) $n=2$



c) $n=5$



d) $n=21$



e) $n=100$

Figure 1. Graphical presentation of trigonometric series given in (4) (5) (6) ((4) red, (5) blue and (6) green curve) for $n = 1, 2, 5, 21$ and 100 , and period from $-\pi$ to π .

From the Figure 1 is clearly seen that the larger the number of terms that are included in this series, the better the approximation to the periodic function is.

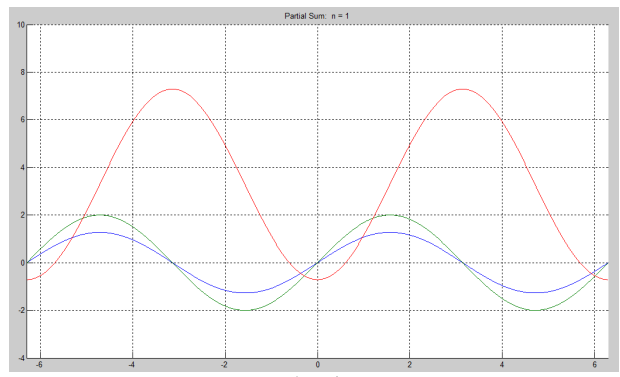
Therefore, when n is large enough we can guess the periodic functions that these trigonometric series present. According to Figure 1 partial sum (4) corresponds to periodic function $f(x) = x^2, x \in [-\pi, \pi]$, partial sum (5) corresponds to periodic function $f(x) = \begin{cases} 1 & x \in [0, \pi] \\ -1 & x \in [-\pi, 0] \end{cases}$, and partial sum (6) corresponds to function $f(x) = x, x \in [-\pi, \pi]$.

The 100-term plot gives a very good approximation to the functions, although it appears to overshoot the value at the discontinuity (and it also has some wiggles in it). This overshoot is an inevitable effect at a discontinuity, known as the Gibbs phenomenon [6]. Gibbs phenomenon can be seen in graphical presentation of partial sums (4) and (5) for large terms (in our case, $n=21$ and $n=100$).

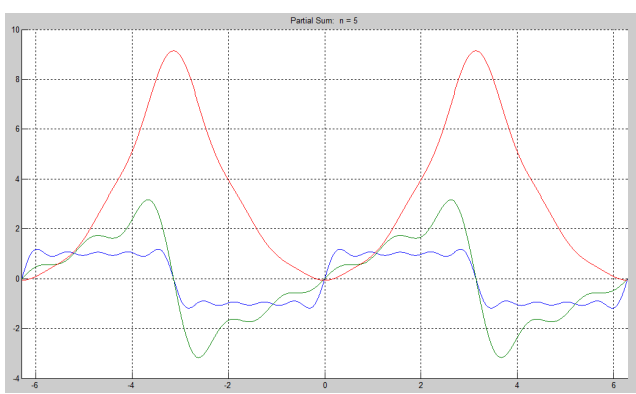
In order to obtain more clear view of trigonometric nature of partial sums and periodic nature of functions, we are presenting trigonometric series in $2T$ period, or x axis are from -2π to 2π . For this purpose we change only a small piece from the code given above.

```
x=linspace(-pi,pi,1000);
axis([-pi pi -4 10])
is changed to:
x=linspace(-2*pi,2*pi,1000);
axis([-2*pi 2*pi -4 10])
```

Partial sums according to this change are shown in Figure 2.



a) $n=1$



b) $n=5$

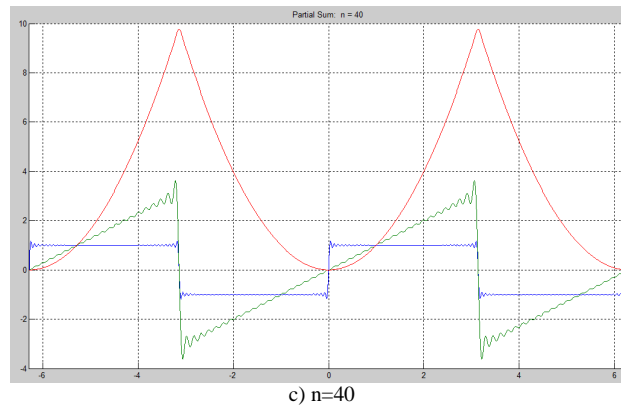


Figure 2. Graphical presentation of the partial sums (4) (5) (6) ((4)-red, (5)-blue and (6)-green curve) for 1,2 and 40 terms and x-axes from -2π to 2π .

In Figure 1 and Figure 2 all previous conditions of curves are deleted.

In order to obtain a precise view of partial sum and the way of curve's changing and at the same time keep previous conditions of partial sum we plot each of three partial sums in separate graphic. All previous conditions of curve are shown in different color.

Following each curve represented by different color can be observed the appearance of partial trigonometric sum for each n .

This can be done with a minor change in code by adding different color in each term.

```
colors = 'rgbmy';
```

and instead of

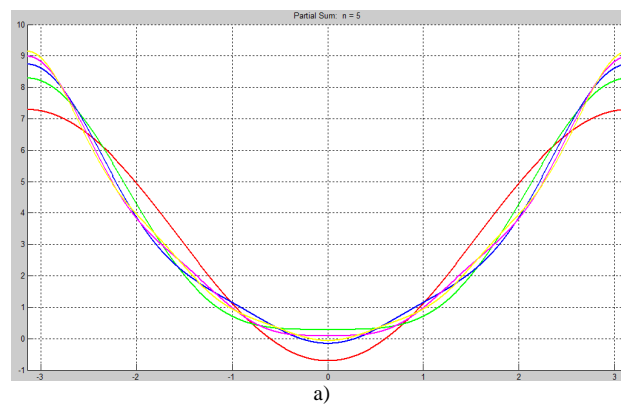
```
pause set(handle1,'Visible','off');
```

is added:

```
pause set (handle1,'Color',colors(n));,
```

where *handle1* is used for plotting partial sum and is different for different trigonometric series (4), (5) and (6) .

All first five partial sums of trigonometric series (4) (5) (6) are printed in Figure 3 a), b), c) accordingly.



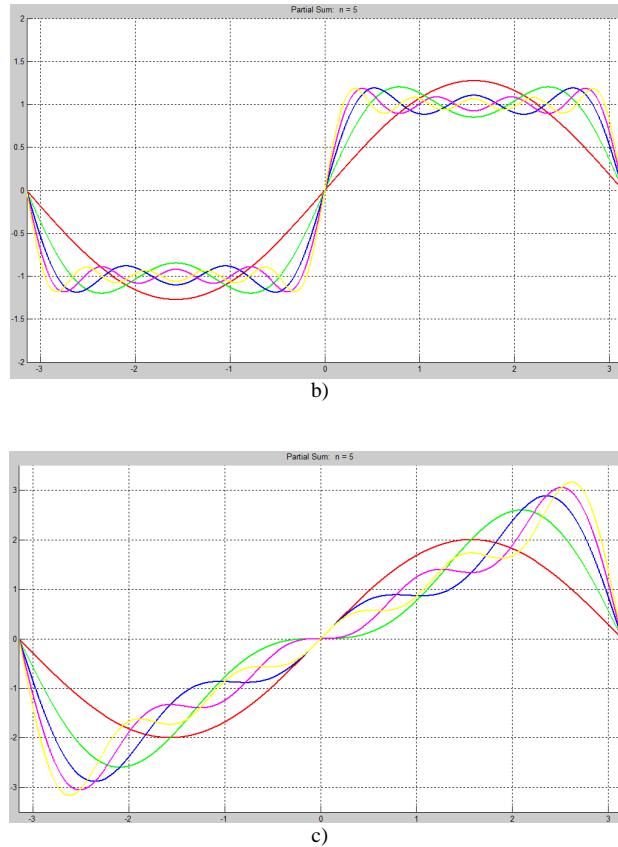


Figure 3. Graphical presentation of first 5 term partial sum a) of (4) b) of (5) c) of (6) red color for n=1, green for n=2, blue for n=3, violet for n=4, and yellow for n=5.

Figure 3 is useful in process of understanding of trigonometric partial sum and Fourier series.

IV. MATHEMATICAL PROOF

Using graphical representations for the given Fourier series we managed to obtain periodic functions, but their correctness will be confirmed with mathematical proof. For (6) we are going to obtain periodic function starting from given trigonometric series.

Partial sum (6) can be shown as:

$$f(x) = 2 \sum_{n=1}^{+\infty} (-1)^{n-1} \frac{\sin nx}{n} = -2 \sum_{n=1}^{+\infty} (-1)^n \frac{\sin nx}{n}.$$

Our aim is to show that $f(x) = x$ on the interval $[-\pi, \pi]$ is the function that is obtained by the given Fourier series.

According to De Moivre's formula, formula that is important because it connects complex numbers and trigonometry $e^{inz} = \cos nz + i \sin nz$ and according to equation

$$\log(1+z) = -\sum_{n=1}^{+\infty} \frac{(-1)^n}{n} z^n \quad \text{for } z \in C$$

we obtain:

$$\begin{aligned} -\log(1+e^{ix}) &= \sum_{n=1}^{+\infty} (-1)^n \frac{e^{inx}}{n} = \\ &= \sum_{n=1}^{+\infty} (-1)^n \frac{\cos nx}{n} + \sum_{n=1}^{+\infty} (-1)^n \frac{\sin nx}{n} i = \\ &= \operatorname{Re}(-\log(1+e^{ix})) + i \operatorname{Im}(-\log(1+e^{ix})) \end{aligned}$$

We start with the Fourier series to obtain the function

$$f(x) = -2 \sum_{n=1}^{+\infty} (-1)^n \frac{\sin nx}{n} =$$

$$2 \operatorname{Arg}(1 + e^{ix}) = 2 \operatorname{arctg} \frac{\sin x}{1 + \cos x} =$$

$$2 \operatorname{arctg} \frac{2 \sin \frac{x}{2} \cos \frac{x}{2}}{2 \cos^2 \frac{x}{2}} = 2 \operatorname{arctg} \frac{\sin \frac{x}{2}}{\cos \frac{x}{2}} =$$

$$2 \cdot \frac{1}{2} x = x$$

Obtaining functions from series (4) and (5) is more complex, therefore we will use a reverse process as a proof. We will start from periodic functions we obtained to find Fourier series they represent.

First example is to find the Fourier series of the function $f(x) = x^2, x \in [-\pi, \pi]$. Because this function is even function, the coefficient b_n has zero value. Thus the coefficients of the Fourier series are

$$b_n = 0,$$

$$a_0 = \frac{1}{2\pi} \int_{-\pi}^{\pi} f(x) dx = \frac{2}{2\pi} \int_0^{\pi} x^2 dx = \frac{1}{\pi} \cdot \frac{x^3}{3} \Big|_0^{\pi} = \frac{\pi^2}{3},$$

$$a_n = \frac{2}{\pi} \int_0^{\pi} f(x) \cos nx dx = \frac{2}{\pi} \int_0^{\pi} x^2 \cos nx dx =$$

$$= \frac{4}{n^2} \cos n\pi$$

For $n = 2k$ is obtained $a_{2k} = \frac{4}{(2k)^2} \cos 2k\pi = \frac{4}{4k^2}$ and for $n = 2k - 1$ is obtained

$$a_{2k-1} = \frac{4}{(2k-1)^2} \cos(2k-1)\pi = -\frac{4}{(2k-1)^2}.$$

Hence the Fourier series for the function $f(x) = x^2, x \in [-\pi, \pi]$ is

$$f(x) = \frac{\pi^2}{3} + 4 \sum_{n=1}^{+\infty} \frac{(-1)^n \cos nx}{n^2}.$$

That is equivalent to partial sum (4).

$$f(x) = \begin{cases} -1, & -\pi \leq x < 0 \\ 1, & 0 \leq x < \pi \end{cases}$$

The other example is to find the Fourier series of the function $f(x) = \begin{cases} -1, & -\pi \leq x < 0 \\ 1, & 0 \leq x < \pi \end{cases}$. In this example we have to find all the coefficients i.e. a_0, a_n and b_n where $n=1,2,3,\dots$

The coefficients of the Fourier series are

$$a_0 = \frac{1}{2\pi} \int_{-\pi}^{\pi} f(x) dx = 0,$$

$$a_n = \frac{1}{\pi} \int_{-\pi}^{\pi} f(x) \cos nx \, dx = \frac{1}{\pi} \left[\int_{-\pi}^0 -\cos nx \, dx + \int_0^{\pi} \cos nx \, dx \right] = 0,$$

$$b_n = \frac{1}{\pi} \int_{-\pi}^{\pi} f(x) \sin nx \, dx = \frac{1}{\pi} \left[\int_{-\pi}^0 -\sin nx \, dx + \int_0^{\pi} \sin nx \, dx \right] = \frac{2}{n\pi} (1 - \cos n\pi).$$

For $n = 2k$ is obtained $b_{2k} = \frac{2}{(2k)\pi} (1 - \cos 2k\pi) = 0$.

and for $n = 2k - 1$ is obtained $b_{2k-1} = \frac{2}{(2k-1)\pi} [1 - \cos(2k-1)\pi] = \frac{4}{(2k-1)\pi}$.

Hence the Fourier series for the function $f(x) = \begin{cases} -1, & -\pi \leq x < 0 \\ 1, & 0 \leq x < \pi \end{cases}$ is

$$f(x) = \frac{4}{\pi} \sum_{n=1}^{+\infty} \frac{\sin(2n-1)x}{2n-1}.$$

That is equivalent to partial sum (5).

And the last and already proven example with reverse process, is to find the Fourier series of the function $f(x) = x, x \in [-\pi, \pi]$. Because this function is odd function, the zero coefficients in this case are: $a_0 = 0$ and $a_n = 0, \forall n$. We only need to find a b_n coefficient

$$b_n = \frac{1}{\pi} \int_{-\pi}^{\pi} f(x) \sin nx \, dx = \frac{1}{\pi} \int_{-\pi}^{\pi} x \sin nx \, dx = -\frac{2}{\pi} \cos n\pi.$$

For $n = 2k$ is obtained $b_{2k} = -\frac{2}{(2k)} \cos 2k\pi = -\frac{2}{2k}$

and for $n = 2k - 1$ is obtained $b_{2k-1} = -\frac{2}{(2k-1)} \cos(2k-1)\pi = \frac{2}{(2k-1)}$.

Hence the Fourier series for the function $f(x) = x, x \in [-\pi, \pi]$ is

$$f(x) = 2 \sum_{n=1}^{+\infty} (-1)^{n-1} \frac{\sin nx}{n}.$$

This partial sum is equivalent to partial sum (6).

These three proves confirms graphically obtained functions.

V. CONCLUSION

Fourier series are infinite series that represent periodic functions in terms of cosines and sines. Because these series can be used in solving different problem in many scientific fields, very important is

process of their understanding. We gave a brief introduction to Fourier series and tried to facilitate their understanding with graphical presentation using Matlab. Also, with these graphical representations we tried to facilitate the way of obtaining periodic functions knowing the Fourier series. This process, using only mathematical equations can be complex and difficult to accomplish, especially to students. Therefore, we tried to easier this process by obtaining functions using Matlab and plotting partial sums. From graphical representation of trigonometric series we noticed that with the large number of terms included in this series, approximation to the periodic function can be very close.

We also gave and mathematical proof that obtained functions from our graphical representation of Fourier series are correct periodic functions.

By using Matlab, students' process of learning and understanding Fourier series is significantly improved. Also this kind of presenting Fourier series is more interesting, easy to use and learn and therefore is easy acceptable by students.

Matlab can be used as tool for different more or less complex mathematical computations with little effort, but in this paper we focused only on obtaining periodic functions knowing the Fourier series. By using Matlab students can benefit in more subjects.

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LESSONS LEARNED WHILE TEACHING DATABASE SYSTEMS FOR APPLIED INFORMATICS STUDENTS

UDK: 371.3:004.6

Review Scientific Paper

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Abstract - The Database Systems course was one of the key subjects of the Applied Informatics study program at our Faculty. By the termination of this specialization, we present our concluding remarks on this teaching subject in the form of presenting the lessons we learned during the lifetime of the study programme. The main point of view for the evaluation presented in this paper is the evolution of the syllabus. We point out the changes in the teaching methods applied and teaching material used, and we express their impact on the subject schedule and students' results as well as the impact of the students and their involvement into the process of syllabi improvement. As conclusion, we generalize our statements to build a set of recommendations usable for future improvements on different software engineering subjects.

Keywords: database, systems, curricula, lecture

I. INTRODUCTION

Teaching Information Technology subjects means endless facing of problems with integration of new approaches and research results into the subject's curriculum [2]. Usually, but not always, one can ask the students about their suggestions where and how to change the curriculum, e.g. selecting some topics already co-covered by another subjects etc.

In the past eight years, we were members of the small group of teachers responsible for teaching different subjects for students of the Applied Informatics study program. This study program is outstanding in several properties compared to the other subjects at the Faculty of Electrical Engineering and Informatics at the Technical University of Košice (TUKE). It is different in the language used – English is preferred against Slovak. It is different by subject selection – subjects are not taught by members of a single department but the subjects cover three areas of information technology represented by three core departments of the Faculty.

The Database Systems subject was situated in the study program schedule in the summer term of the second year. For those students who did not pass the exams in the regular year, the subject is open in the last (shortened) semester. The subject is popular between the ERASMUS+ exchange students as the lectures cover different areas of database design and theory and are organized by topics. Taking a subset of them only is suitable for short-term visits such as via the CEEPUS program too, because the relations between the topics are low, and the missing knowledge (if there is any) can be obtained by short reading.

This paper is devoted to the findings achieved during the past years with the students of Database Systems subject within the Applied Informatics study program. The number of the students was quite low – only a small group every year, but their contribution to the evolution of the study material and curricula is significant.

The structure of our paper includes Sec. II on our incremental curriculum life cycle, which is a detailed description of issues and stakeholders, and a conclusion (in Sec. III), which points out the benefits we received from our students and could use to improve mainly our strategy in building curricula for other subjects.

II. OUR INCREMENTAL CURRICULUM LIFE-CYCLE

A. Teachers

Teachers of the Database systems subjects are the authors of present article. The teaching experience was built on teaching courses on different types of database management systems such as Informix and Oracle [9] for different organizations – Technical University of Košice, T-Systems Company, University of Ss. Cyril and Methodius in Trnava, and our learning experience from different courses was used in this process also.

Visiting professors usually teach one week – if they choose this subject, it means a new lecture topic. As Database Systems is a general subject, during the years several visiting professors presented their lectures on selected topics in databases.

B. Students

There were four categories of students at the subject, where these categories are defined by the way the students came to the subject:

- Regular students. These students enrolled regularly at the subject as they had it chosen from the study program's list of facultative subjects. This category is typical, only a subset of the students really uses the achieved knowledge in further studies or future life.
- Students with individual study plan. These students are usually foreign students who can decide about the content of their study plan during a negotiation period. Regular students can also apply for individual study plan in the case of serious reasons such as family or health condition. After finishing the subject, these students usually apply the achieved knowledge in further studies, in their diploma theses.
- ERASMUS exchange students. These students select and negotiate their study plan one semester in advance, but there do not apply the requirements (e.g. prerequisites) for regular students to them. These students present their motivation for selecting the subject variously – they usually need to refine their knowledge in this specific field or there is a similar subject at their home university.
- CEEPUS exchange students. This category of students visits our Department for a short term (e.g. one month). These students join the group of other students for four weeks, they benefit from the teaching material if they need to prepare something for a specific subject at their home university.

C. Lectures

We follow the logic that a lecture should be always before the lab, but it already happened to our subject that the generated schedule did not meet this criterion perfectly. In past years, lectures and labs even were scheduled for two different days, but since the last year, the schedule got fixed for Thursdays. Fig. 1 presents the schedule for the current year.

The contents of the lectures developed during the years. The most important change to introduce was the one dealing with the variety of the students' knowledge – to provide a material useful to all of them and to allow attendance at selected topics only. This means that we had to prepare as complex lectures as possible, which we hope we did. Unfortunately, there are topics that require knowledge of another topics, and topics that we had to split across two lectures (these are larger than to be presented in 90 minutes). The

Deň	HODINY				
	06:00 - 07:30	12:30 - 13:15	13:15 - 14:00	14:15 - 15:00	15:00 - 15:45
Pondelok					
Utorok					
Streda					
Štvrtok		Databázové systémy DBS L9-B_510 Ing. Csaba Szabó, PhD. P AI		Databázové systémy DBS L9-B_515 Ing. Csaba Szabó, PhD. CL AI	

Figure 1. Database Systems schedule for ST 2014/2015 (P – lecture, CL – lab)

next problem we had to face was the level of students' skills. We solved this problem by decreasing the

requirements on programming skills and by increasing the requirements on database design skills. (The same we applied in the case of the labs and exams.)

The topic-based structure of our curricula is as follows:

1. Basic concepts
2. Data modeling
3. Relational data model
4. Relational algebra
5. Normalization
6. SQL
7. File organization
8. Indexes
9. Transactions
10. Concurrency
11. Security
12. Distributed database systems

All these topics undergo a reviewing and correcting phase every year to ensure the best acceptance by the students.

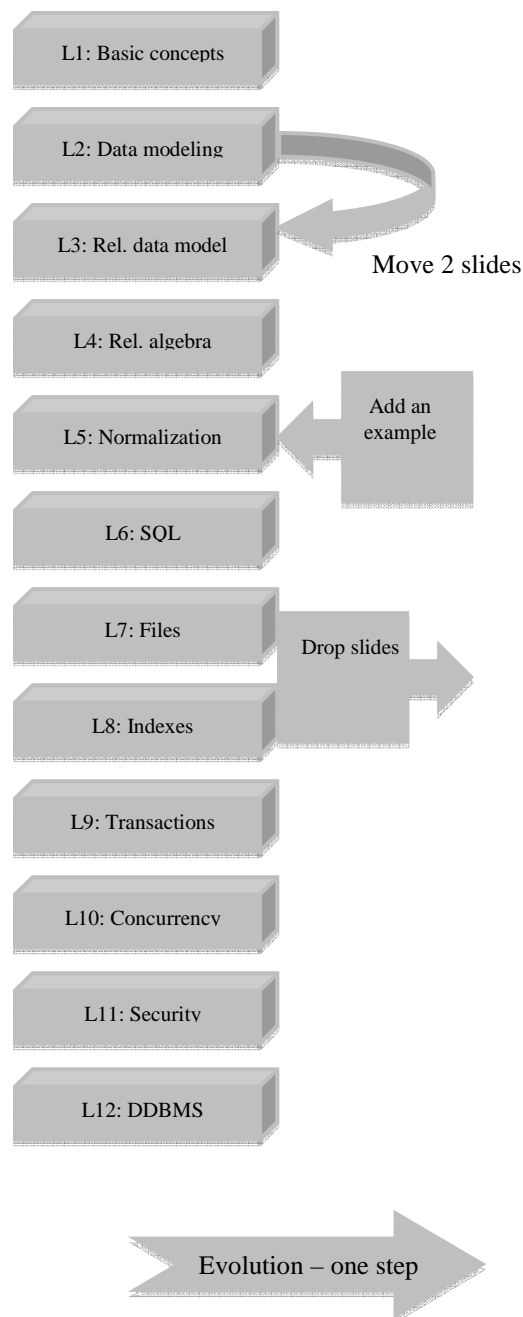


Figure 2. Database Systems lecture evolution

Fig. 2 shows the details. The content of this figure denotes one increment of our curricula with the changes provided based on the above-mentioned structural requirements.

D. Labs

To maintain diversity, we decided to minimize the interconnection between the material taught at the lectures and the practical examples presented and analyzed at the labs.

Initially, we focused on various aspects of SQL using the dialect implemented in Oracle 11g, even selected parts of PL/SQL were practiced. Later, we decided to remove topics related to triggers and stored procedures from the labs' material. Our decision was based on the experience that this is a kind of different and more advanced topic than we could expect from a subject dealing with database systems' basics. The actual content of the lab material focuses purely on SQL and closely related topics, such as DDL (data definition language), DML (data manipulation language), DCL (data access control language), TCL (transaction control language) and RA (relational algebra [8,11]). RA is closely related to the lectures from the above list only. This change also influenced the tasks for the students.

The basic idea of the database systems task was to design a database schema for a specific purpose and to also develop a CRUD application (client-server architecture). This pattern for the tasks was modified during the past years to gain its actual form:

The students have to design a database schema from scratch – they begin with a set of data. This schema has to be transformed into (at least) 3NF (3rd normal form) [3], and then filled with the original data. It is required to hand in the database scripts including all DDL, DML, DCL and TCL statements used by the student. This step could be implemented in a different way too, but there was no student applying database refactoring [4] until now. The schema has to fulfill additional requirement such as extended integrity criteria or usage of sequences. The second part of the task is to write equations of relational algebra for specific purposes defined in the body of the task definition, which RA equations have to be then transformed into SQL SELECT statement and compiled as VIEWS into the database.

In addition to the above-described task, the students have to write an essay on selected topic of database systems such as Armstrong’s axioms, different data models or federated databases. The purpose of these essays is to teach students additional details on selected topics that are not covered by the lectures. This section also opens the horizon for actualization in specific fields – involving students into the development of the lectures and other course material.

At labs, we also evaluate student activity. The conclusion of lab activity evaluation is shown in Fig. 3 of our electronic supporting system. The limits for success at the labs are 16 points at minimum and 30 points at maximum.

E. Exams

Since we have developed a very nice electronic system [7] that supports our activities, we rely on it also in the case of the exams. Partially. The reason is that during the past years of using electronic systems for examination we found out that the students forgot to “speak”. Our experience shows that the majority of the students are unable to talk continuously about a selected topic – even a sequence of five sentences is a problem sometimes. We decided to change this as well, therefore we returned to the system of exams from the times before the electronic supporting systems’, and we combined these two approaches as follows:

- The electronic system is used for the electronic test [1], which is the first part of the exam. It weight is 50 of 70, i.e. the students can achieve at max. 50 points from the electronic test, while the maximum points for the exam is 70 in total.
- The second part of the exam is verbal, where the student has to answer two questions. This part is mandatory; the student cannot say she/he is satisfied with the score from the test alone – not attending the second part implies failing the exam. The main topic area of the question is selected randomly, the discussion then covers a specific part of the topic area. Weight of the verbal part of the exam is 20 of 70.

We started with optional verbal part of the exam, but our students did not attend it, which was then reflected in the average results. This is not a good strategy at all, because sometimes the verbal part is more successful.

F. Electronic supporting systems

The roots of our electronic supporting systems are the modular academic information system used at TUKE and LMS Moodle at our department. As we need to communicate with the students, we also use

AI - lessons Iba súhrmné známky						
Zadanie (2.2) Essay upload Triedit' zostupne	Zadanie (2.2) Project upload Triedit' zostupne	Manuálna položka Activity Triedit' zostupne	Test Test AI Triedit' zostupne	Súhrmná známka	Katégoria spolu	Triedit' zes
12,00 Grade analysis	7,00 Grade analysis		2,00	-		Grade analysis
12,00 Grade analysis	7,00 Grade analysis		2,00	-		Grade analysis
12,00 Grade analysis	11,00 Grade analysis		4,00	-		Grade analysis
12,00 Grade analysis	7,00 Grade analysis		1,00	-		Grade analysis
12,00	8,00		2,25	-		

Figure 3. Database Systems labs grading detail

Termíny, ktoré sa ešte nekonali				
Dátum a čas	Miestnosť	Predmet štúdia	Popíska	Stav
14.05.2015 12:00	L9-B_510	Databázové systémy	Exam	6 / 18
21.05.2015 08:00	L9-B_510	Databázové systémy	Exam	0 / 18
28.05.2015 08:00	L9-B_510	Databázové systémy	Exam	0 / 18

Figure 4. Database Systems exams' list detail

university e-mails (students have to use the assigned mailbox).

The incremental property of the evolution is related to improvements in the question base [12] in LMS Moodle in three different aspects:

- Updating the question content [5]
- Adding new question types [6, 10]
- Updating previously added question types

All above-mentioned actions are performed even immediately based on the situation.

Using the university information system, we get the list of students registered for the subject, for schedule, and for the exams; we can also make evidence on attendance at lectures, labs and exams and we can use this system for grading of lab activity and exam results (a small example is shown in Fig.4).

G. Evaluation criteria for starting a new iteration of the incremental life-cycle

This subsection presents the most important part of the article, the criteria used to start a new iteration of the curricula and teaching material development. We had several of them as listed below:

1. Which were the easiest lecture topics?
2. Which were the hardest lecture topics?
3. Which essay topic is suitable to be included with the lectures?
4. Which were the most problematic labs?
5. Which were the easiest labs?
6. Are there errors or ambiguities in the questions?

The evaluation of the above criteria was always performed in relation to the count and results of the students, e.g. if a single student claims a problem with a specific topic only, then this is not a real stimulus for an iteration. Data collection was always realized immediately the student finished the first exam (exam results were not taken into consideration).

For Item 1 and 2, we asked each student to select exactly 3 topics of a kind. The student also had to define his own order of his selection. If there was a match on topics in between at least 20% of the students, we analyzed and refined the content of such lectures.

With Item 3, we asked the students at the labs. Only a match above 50% was considered as worthy for further processing. Mostly adding several new slides to existing lectures – not by replacing any of the original slides, made improvements.

Answers related to Items 4 and 5 were handled similarly as those for Items 1 and 2. Changing the labs was implemented by adding, removing or changing examples and tasks; or by changing an example to a task or vice versa.

Item 6 was more specific, because these kinds of errors were detected during using the system – some of them were reported at exams or in-semester-tests. Improvements in specific questions could be usually implemented in the moment of the identification of the source of the problem; others started a real development cycle such as in the case of execution failures of new question types.

The most important outcomes of involving the students were that they also suggested the way of improvement and (in several cases) the students themselves wanted to implement these improvements in the form of Bachelors' theses.

III. CONCLUSION

The Applied Informatics study program at the Faculty of Electrical Engineering and Informatics at the Technical University of Kosice can be evaluated as a successful study program. The Informatics related subjects do not build a complete unit at all, but the Database systems subject acts in a sovereign way.

The past years of curricula development, of endless improvement of the question banks and development of supporting tools led to something we can be proud of. Unfortunately, the new accreditation does not include this subject as there was the Applied Informatics program removed from the accreditation.

The English version of the lectures, labs, tasks, question bank and other course material will be now less developed – mainly only based on the requirements of the several CEEPUS and ERASMUS+ students who enroll this subject in the future.

We would recommend involving students into the development of the new learning material as the students know the best how they would like to learn. And, how they might be able to gain the maximum from the study material. It does not mean that we should completely rely on the students' results such as essays, but these could be used to evaluate several possible directions in curriculum development. Asking the students using an anonymous questionnaire about the easiest and hardest topics presented serves with the most objective answers to the question "is it enough, or is it too much?"

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THE EFFICIENCY OF APPLICATION OF INFORMATION TECHNOLOGIES IN TEACHING AT HIGHER EDUCATION INSTITUTIONS IN REPUBLIC OF SRPSKA

UDK: 371.3:004
Professional Paper

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Summary – By introducing the information technologies in the teaching process, there has been a change in traditional teaching. The use of information technology in the teaching process encourages the improvement of the quality of teaching. The application of information technology at higher education institutions in Republic of Srpska has great significance and important educational effects for both teachers and students.

Keywords: information technologies, teaching process, educational software

I. INTRODUCTION

Information technology (IT) is a technology that uses computers for data collection, processing, storage, protection and transmission of information. The term information technology is associated with communication technology as today it is impossible to operate with the computer if it is not connected to a network, and so the term information and communication technologies (Eng. Information and Communications Technology - ICT) is introduced.

Higher education is neither technical nor economic issue, but above all, a matter of survival, the question of development opportunities and prospects for freedom and happiness – of individual, communities and nations. [10] The reform of the higher education should be a development imperative. For this reason, the aim is to change the content of education in general, and particularly in higher education. The main task of higher education is that young people are professionally trained for work that they will encounter later. It should never neglect the shaping of the young man as a person, as well as his ability in the future to constantly build its social and professional knowledge.

The problem of the entire educational system is that over time the volume of material that the student must adopt has increased and a way of teaching has not changed for centuries (changes have happened, but in the essence the principle is still the same).

The traditional teaching is the most common frontal form of work with a strong function of teachers lecturing and it leaves no space for interaction between students or leaves time for independent activities of students in the function of better realization of teaching contents. Teaching is usually formalized, verbalized and for pupils hard to understand, which reduces the durability of knowledge and ability to use theories in real life.

However, in the last ten years, massive use of computers in schools created conditions for better educational technology innovations. Multimedia programs designed for personal computers offer us a variety of options for electronic books with text, images, animations, sound and movies, so that students can progress independently in mastering the syllabus, they can return the content that they are not clear enough to receive feedback and additional information in accordance with their capabilities and interests. Interactivity and quality of the presented material by using multimedia and hypertext provides much more extensive facilities in comparison to teaching that takes place in traditional classrooms.

II. THE DEVELOPMENT CONCEPT OF INFORMATION TECHNOLOGY

By using the information technology, the main didactic concept gets extensive form in which the reversible routes, apart from students, professors and teaching content equally participate in information technology methods, forms and principles that change the educational paradigm. Fig.2.

The new educational paradigm is oriented towards the students, which is located in the center, while is surrounded with learning resources both in terms of time and place and ways of learning.

Digitalization of existing scripts or textbook students come easily to the learning materials. The possibility of faster searching throughout the textbook increases the importance in exploiting the teaching material. Materials in electronic form ease students the process of facilitates routine operations copying and formatting, because for these purposes they use software tools.

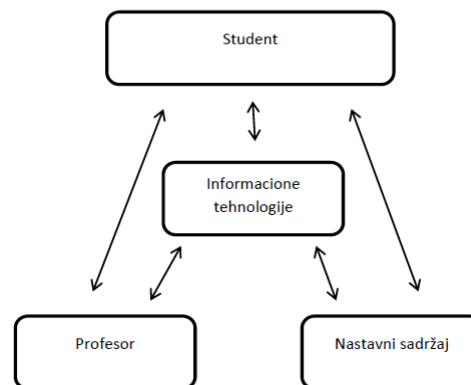


Figure 1: Pedagogical paradigm of teaching

III. THE APPLICATION OF MODERN TECHNOLOGIES IN TEACHING PROCESS

The more powerful, more minimized, simpler to manage and cheaper information technology brings great changes in education.

The teaching process at higher education is in between of constant organizational changes and changing technologies of educational work. Innovation in teaching is a novelty introduced into the educational reality.

In the educational process, information and communication technologies represent a very important part. Information technologies go through all areas of school work and activities, both in the field of administrative work, communication, archiving data in electronic form, to the application of information technology in the teaching process. In the educational process, information and communication technologies represent a very important part. Information technologies go through all areas of school work and activities, both in the field of administrative work, communication, archiving data in electronic form, to the application of information technology in the teaching process.

Information technology represents the "study, design, development, implementation and support or management of computer information systems, software applications and hardware." [6]

Under the information technologies in education, the study of characteristics and possibilities of electronic information resources and adequate implementation of modern didactic media in the function of innovating technology teaching and learning, is considered.

The educational process, which is carried out with the help of information and communication technologies in practice, can be found under the term e-learning. E-learning can be characterized as a way of learning using information technology, as the performance of educational process with the help of information technology or as ELECTRONICAL aided learning.



Figure 2: E-learning

The installation of application programs, networking and engineering computer hardware, designing software and databases, as well as designing complex computer networks and information systems belong to the domain of information technology. The application of information technology in education is crucial, because proper acceptance and understanding of the concept of information and communication technologies, and the creation and implementation of partial segments, represents one of the imperatives of modern society ready to respond to the demands of the modern age. Results of previous studies show clear benefits of ICT in the teaching process compared to traditional teaching, both in terms of quantity and in terms of the quality of the acquired knowledge, its durability and applicability, and greater engagement in the learning process, the development of abstract thinking, the ability to process learning, the ability to grasp, solving the problems and creative potential, which effectively puts knowledge of the development of human capabilities. [7]

More frequent application of digital technology, application software, as well as greater representation of multimedia classrooms at universities in the Republic of Srpska, testifies on more and more improved and modern teaching process.

Based on its implementation, information technology in the teaching process, ensures time and relevant information provided by monitoring implementation of the education process, and making time significant decisions, as well as the high standard of teaching staff and students during their education in part of creating, storing and sharing information and knowledge.

The use of information technology in higher education is aimed to modernize the existing technology, monitor new processes, and young professionals which are educated in accordance with the needs of society and the economy.

The current trends in the introduction of information technology show that their use has been to maintain a higher concentration of students compared to the traditional way of teaching. The traditional form of teaching, where the lecture is the central part of the teaching process, is undergoing through changes by introducing information technology in teaching.

Computer devices enable a completely different organization of teaching and educational work, appropriate abilities and interests of each student, then provide better and more efficient, emission, transmission and absorption of knowledge. Experiments have also shown that in terms of quality and quantity of acquired knowledge, the durability of that knowledge, teaching and learning with computers is more effective than traditional teaching.

Computer teaching and learning is suitable to the development of abstract thinking, enabling planning direction and individual progress in acquiring knowledge.

IV. THE IMPROVEMENT OF THE EDUCATION PROCESS BY APPLICATION OF INFORMATION TECHNOLOGY ON ORGANIZATIONAL UNITS OF THE UNIVERSITY OF EAST SARAJEVO

The application of information technologies in organizational units of the University of East Sarajevo can be seen in all segments of the organization starting from the management till teaching process.

The Bologna process, which for many years applied to the University of East Sarajevo puts students in the focus of education strategies with an emphasis on learning outcomes. Practically, it represents that the attention shifted from the center of gravity: what information content is given to students during the educational program, focus on what knowledge, competence and skills of the student have after graduation.

The rapid and dynamic development of information and communication sector imposes the need for consolidating the efforts of higher education institutions and information company in order to improve the

knowledge and competence of students of traffic engineering, in order to be ready for inclusion in the ICT labor market.

The need for the use of information technology in various faculties are reflected in the possibility of covering all information flows in the managing of the education system, in accordance with the tasks that are performed in the system.

Since information systems are expected to provide the basis for the execution of various tasks and requirements that participants set to the system. Thus there is a need for complex and efficient information technologies required to design, construction and operation of information systems. [5]

Information technologies have become an indispensable element in the development of society, and therefore recognize the need to apply in the management of higher education institutions is one of the key factors for its further development and inclusion in the modern trends of modern society. Management of information technology has become part of the policy and management at the highest level of the University. It follows that the very success of the University depends on the quality of organized and designed information system. Well-organized and built an information system makes it easier to manage and is suitable for employees of the University and in largely the same for students.

Information technologies have become an important element in the development of society, and therefore the recognition of the need to apply in the management of higher education institutions is one of the key factors in the further development and inclusion in the modern trends of modern society.

Strengthening of information structures in the Faculty of Transportation in Doboj contributed to the purchase of new computers for computer rooms, classrooms, laboratories, a library, and fixed projector, projection screen, personnel and group printers that enable easier teaching at this University organizational unit. Well educated traffic engineers in information technology are very much needed personnel in all business segments, in order to keep pace with the rapid technological changes and provide benefit in business.

Digital and media competence, the development of educational portals, establishing online services, development of platforms and educational materials related to the curriculum, determining the virtual learning context, the possibility of electronic exam application and application of electronic student identification cards represent different aspects of the integration of information and communication technologies in the organization of instruction in higher education institutions, making it more efficient, better quality, most innovative and globally relevant. The gradualness and continuity in education management of higher education institutions for the implementation of software solutions in the management of universities, as well as Monitoring and Evaluation of ICT strategy project at the level of the education system are based on the implementation of ICT and new pedagogical paradigms in higher education.

In the field of information technology in education, is currently the most important application of computer software. Under the concept of educational software means the finished computer program that can be used in teaching and learning based on logic and pedagogy.

Software for interactive learning allows students to follow the lectures, ask questions, answer questions and communicate with each other. The screen shows an active participant of the conference and the cameras can be posted to all classrooms so that communication can be performed in real time. Use of this software is especially acceptable to related faculties where students can exchange information and teachers to gauge the content and team work on the planning and implementation of teaching.

The Above conducted research studies show that teaching the use of information technology is more efficient than traditional lecturing by up to 30 percent, as it keeps a high level of concentration of students.

The use of information technology in education is not transient and represents much more than combining these technologies with traditional nastavom. Primjena computer in modern teaching becomes the norm, and the most prominent place is given to the application of educational software.

First of all, in order to successfully prepare students for their careers in a dynamic and very demanding field of ICT, it is essential to continuously introduce certain innovations in content items that provide technical knowledge. Students are expected and additional competencies and skills to enable faster and

easier inclusion in a real business environment for teamwork and the like. In realization of these goals, close and continuous cooperation between the ICT sector and the academic community is inevitable and essential.

V. CONCLUSION

The teaching system will inevitably have to be adapted to the changes in education which have emerged from the influence of information technology. The main objective of introducing information and communication technology in the educational process is fast, accurate and reliable knowledge acquisition.

Equipping classrooms with computer equipment and turning them into "digital classroom", as well as ongoing training and development of teachers to use such classrooms create the necessary preconditions for massive use of information communication technology in the teaching process. Application of informational and communication technologies has its place in the modern classroom. Today's generations of students are computer competence and have shown great interest in the use of modern technology.

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DEVELOPMENT AND EVALUATION OF VIRTUAL LABORATORY FOR ENGINEERING EDUCATION

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Original Research

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Abstract – Practical component is often considered as one of the most important characteristics of the engineering education. In this context engineering education laboratories play very important role, by helping the students to test theoretically acquired knowledge, enabling them collaborative environment, trial and error learning approach and offline analysis of the experimental results. However, permanent availability of the laboratory and the equipment is one of the main problems in the process of learning. Sometimes, they are even completely missing.

The rapid development of information and communication technologies in the last decades has made a huge impact on the education system with a special emphasis on the engineering subjects. The advances of web technologies on the other hand have also significantly improved online and collaborative learning, and students' learning experience in general.

This paper presents a developed virtual online laboratory that aims at helping high school students in learning physics. It consists of several virtual benches developed as separate fully interactive web modules. The benches were developed to follow the high school curricula of the physics courses in Macedonia. The design and development technologies and system architecture are also presented. The laboratory has been evaluated from both students and teachers. The results of the evaluation are also presented in the paper and conclusions are drawn.

Keywords: engineering education, knowledge, Virtual Laboratory, education

I. INTRODUCTION

The project described in this paper explores how to create a virtual lab environment that would be interesting, interactive, easy to understand and accessible to students and teachers in order to facilitate the study of physical phenomena in certain areas.

Macedonian education reforms were applied on several occasions, but the conventional teaching, books, blackboards and notebooks generally retained its place at most classes. In addition, there is a very small proportion of schools with modern and highly equipped laboratories; at most schools the laboratory equipment is outdated, and at some there are no labs at all. To enable a modern laboratory, a large budget for the schools is needed. In R. Macedonia a very small portion of schools operate this budget and those are mostly private schools, whereas the majority of the education is provided by public schools with very small budget. To solve these problems, an alternative and better approach is taken, that is design and implementation of virtual laboratories.

Also in the framework of this project, the students are provided with self-evaluation questionnaire and exercises.

Assistance for the laboratory is provided in text format as well as a theoretical support for the topic that the laboratory exercise presents.

II. MAIN OBJECTIVE AND THEORETICAL BACKGROUND

A. Discovery learning and Constructivism

Discovery learning is a very common way of learning new things. By means of learning through research, people acquire knowledge without being aware of it. It is an inquiry-based, constructivist learning theory that takes place in problem solving situations where the learner draws on his or her own past experience and existing knowledge to discover facts and relationships and new truths to be learned. Learning through research and discovery is almost without any effort for the student.

Discovery learning takes place in a problem solving situations where students interact with the world by exploring and manipulating objects, asking questions, or performing experiments. As a result, students are more likely to remember concepts and knowledge discovered on their own. The models that are based upon discovery learning model include: guided discovery, problem-based learning, simulation-based learning, case-based learning, and incidental learning among others.

In our case, emphasis is placed on simulationbased learning.

The development philosophy of learning argues that the most important role of the teacher is to provide students an environment in which they can engage in spontaneous exploration and exploitation. This environment should provide opportunities that will motivate and activate the students. All students have different development processes and should gain understanding and knowledge through their own experiences.

The act of learning is an active process in which errors and problems emerge which needs to be resolved. Both students and adults are involved in something called constructivist learning method, if the originality of what they are learning is close enough to their real world experience.

Constructivism includes active participation and involvement of students in the practical experience of activities at some stage in order to make the learning experience more real. Constructivism should be used in the design of simulations for learning. For interactions in simulations it should:

- help students to understand the relationship between the objects, issues, causes and effects.
- make and keep students engaged and motivated.
- improve students understanding of what is simulated [1].

B. Observations and theoretical approach

Conducted observations have shown that simulations can be very interesting educational tools. However this requires the interaction of students with the simulation to be directed and governed by the interests and questions of the students. The simulations can be effective for teaching all ages of students from primary and secondary school, to university students [2].

Also it is found that the simulations help students overcome cognitive limitations that come from personal, often erroneous, systems of belief to natural phenomena derived from their own life experience [3].

Simulations reduce the cognitive load on students and makes learning more efficient by allowing students to avoid the language barrier of high technological terminology that is common in the classroom.

Students feel more comfortable and more accurate when describing the physics with the help of simulations, instead of using the terminology of the textbook [4].

This means that the design and implementation of simulations should be taken to ensure that the student fully understands the simulation, the student should not get the wrong impression or be misled when simulation is finished [5].

In general, students who have highly developed abstract reasoning benefit more from learning based on simulations. But also necessary steps should be taken to enable students who have less developed abstract reasoning to handle and understand these simulations [6].

III. DESIGN OF VIRTUAL LABORATORY

In the design of the simulation two specific things are considered: Coherence Principle and Consistency. Coherent principle argues that simulations may not contain unnecessary material that distract the student thus disrupts the learning process. Consistency between simulations is also very important. Users who have more experience with simulations will learn to use simulations faster if they have a consistent design [1].

With the simulations, students are provided with animated visual model for easier understanding of the physical phenomenon. By doing interaction with the simulation, the student can participate in changing the parameters and analysis of results. Therefore, it is necessary to take into account the design of the simulations, because students give equal importance to the overall visual design [7].

Simulations are not supposed to reflect the reality in details, but to maintain the concept of the physical area that they simulate. For simulation to be sufficiently realistic it is necessary to:

- implement connections and principles of the system which simulates;
- contain components with enough detail for the user to connect to the same components from the real world;
- allow the user to change parameters like in the real system;
- give the user the feeling that he or she directly controls the components of the simulation without any intermediate steps.

In short, the simulation should function as the actual system. Moreover, it should offer:

- a single and clear goal for the user;
- objects that can be interacted to successfully complete the simulation;
- environment that provide an appropriate context in the simulation;
- interactions, reactions, challenges, situations and effects that are equivalent to those of the real experiment;
- a feedback after the simulation or the task is completed successfully;
- opportunities for returning simulation in initial state or to a previous state, such as back button or restart;
- allow users to have a sense that they control the application.

The interface should be as consistent as possible, but some simulations may require variations. The basic structure is a large working area and a control panel. Working area contains animations and objects that can be manipulated directly, while the control panel contains other control devices such as sliders, radio buttons, text fields and so on. The difference between the working area and control panel is clearly visible, with a different background color and borders [6].

In the design of the control panel, attention has been devoted to the limited amount of tools and their schedule.

Text is avoided in the work area or it is reduced only in short label.

The background of the simulation is usually in one or two colors not to cause too revocation of the student's.

Keys for controlling the simulation - start, pause, stop or resume are simple animated and large enough for easy navigation [6].

Students should not have to think much about how to use the simulation. To make it easy to understand the developer should provide the following:

- Useful feedback in response to user input.
- Understandable and intuitive ways to interact with the environment.
- Clear and easily understood instructions.
- Appropriate and sufficient help

Controls in the simulation should be intuitive and easy to use; otherwise the students can be directed and focused on understanding the controls and how to work with them, rather than on how to deal with the concept presented by the simulation.

The most natural way for students when working with mouse is by clicking and dragging. This means that the student will first try to click or grab an object in the simulation. [6]

Using the point-and-click interaction, proved to be much more effective, especially in applications where such interactions are many.

Generally grabble objects, sliders associated with numerical values and radio buttons for switching on and off are functionalities that are understandable for students.

Sliders should be used in conjunction with a numerical value that students can change directly using keyboard input, as using the slider. Usually students would start working with slider to see what effect it has on simulation. But later, when, for example perform lab assignments, students sometimes prefer to enter specific numerical values through a digital input.

Students also immediately understand the use of radio buttons, but check boxes can sometimes cause confusion. [6]

It is important toolbar interface to be more consistent as possible for different simulations, otherwise experienced students may become confused if the same group of tools in two different simulations do not look alike [6].

The help should also be as short and concise as possible. Some researchers found that help provided in several steps is ineffective, therefore help for the laboratory needs to be clear and concise but it is also important not to make it too prominent which may lead to users not exploring the environment by themselves. It is also required to remain on screen while the student continues to interact with the simulation but must not interfere with the interaction in any way.

In the simulations, "help for the simulation" is provided for the use of simulation. The "read more" provides assistance to theoretical entity that describes laboratory exercise and gives more information about the theoretical aspect and what should be learned from the simulation. Both are optional and appear on students' request.

For encouraging exploration, a "check your knowledge" button is provided with a self-evaluation question mark [6].

"Check your knowledge", is a short quiz that asks questions and offers answers. Through the quiz the student have the opportunity to use the simulation, and thus to check all the possibilities it offers in order to accurately answer the question, or select the correct answer. Students have to answer all questions. Once questions are answered, the student is given the opportunity to check whether there are answered correctly or not. If not, the correct answers are presented. This is to avoid frustration by answering a questionnaire multiple times to obtain all correct answers.

IV. IMPLEMENTATION OF VIRTUAL LABORATORY

A. General imlementation issues. Used Tools

There are various types of applications with the same purpose, but they are generally made in older technologies or technologies that are not very used (in extinction), some are made as multimedia applications that require a portable disk (CD, DVD or USB flash drive) or installation. Online simulations offer some foreign websites that are not on the preferred language, nor designed in order to attract the attention of the students and help them.

In the creation and implementation of the laboratory are used newer web technologies such as HTML5, CSS3 and JavaScript programming language. These technologies are selected for their abilities and the direction in which web technology moves. These technologies are available and free to use. According to the browsers statistic [8] most used browsers support all the definition for HTML5 and CSS3 and because of their great implementation in web browsers, the simulations made in these technologies allow 99% availability and accessibility, except for some older browsers that do not support these technologies.

An exception is made in graphic design of the simulations, the working area is on top, and control panel is below the working area, and it can be fully visible on the small size screens like laptop (15 inch) and multimedia devices - tablets with screen sizes of 10 inches. The application is not designed for mobile devices, because the screen is too small. However this is not a disadvantage because the purpose of this simulations is for education.

Virtual laboratory that is implemented consists of multiple simulations from different areas of physics, in order to provide conditions for performing experiments by the students of secondary education (Figure 1).

It is a web site with a structure which is represented in Figure 2. The simulations are presented with a picture and a text description of the topic they represent. The image and text are linked to the page where simulation can be directly started.

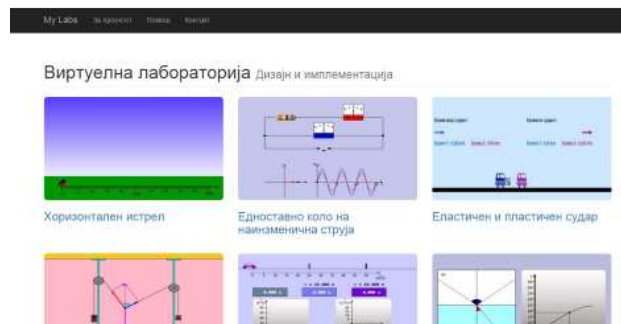


Figure 1. Site diagram for Virtual laboratory

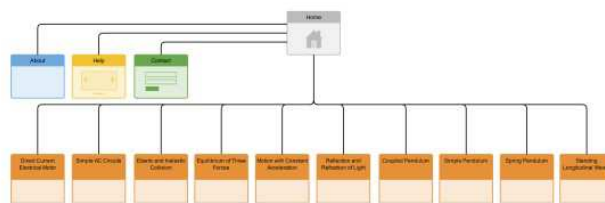


Figure 2. Site diagram for Virtual laboratory

In the following we will describe three simulations that are part of the laboratory. The simulations are designed following the recommendations given in the previous topic.

B. Simulation: Elastic and inelastic collision. Law of preservation of momentum

This simulation is designed to describe the physical law of preservation of momentum (Figure 3).

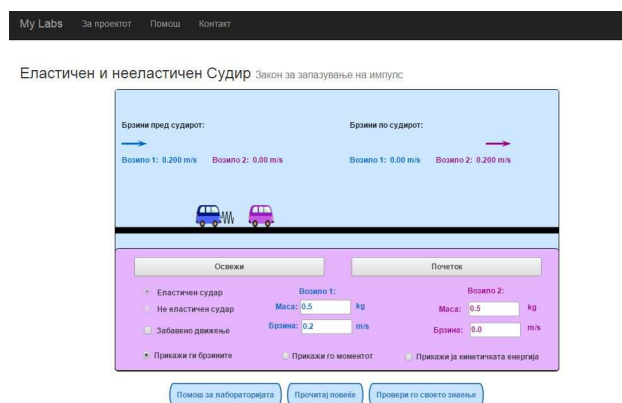


Figure 3. User interface for the elastic and inelastic collision lab exercise

By clicking on the image or the title in the homepage of the website, loading of the web page begins with a scene that has work area and a control panel for the implementation of the exercise. The work area contains the animation and output values, and the control panel contains all control and input fields. As

digital inputs are the fields for entering the mass and speed of vehicle 1 and vehicle 2. The controls for the selection of elastic and inelastic collision, as well as output details for speed, momentum and kinetic energy before and after the conflicts in the panel are represented by radio buttons. The possibility of "Slow motion" is a check box, to be distinguished from the other options because its functionality is independent of the description of physical phenomenon, it only slows the animation 10 times in order to analyze the type of collision slower.

Buttons for start and reset of the simulation are with simple mouse over animation and are with sufficient size to be readily visible.

Under the panel the buttons for "help for the simulation", "read more" and "check your knowledge" are placed.

On load of the site, default values are set for the parameters needed for simulation to function.

Extreme cases are limited to certain values of the masses and speeds of the vehicles, but they realistically reflect the desired outcome.

1) Use case diagram

Use Case diagram for this simulation is shown in the Figure 4. This diagram is a representation of a user's interaction with the system that shows the relationship between the user and the different use cases in which the user is involved.

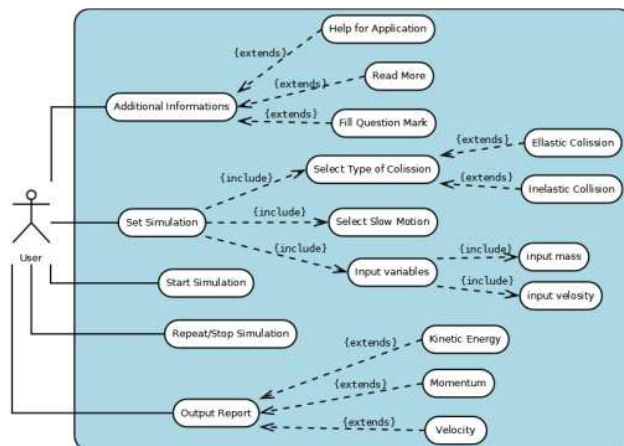


Figure 4. Use case diagram for simulation elastic and inelastic collision

The use case shows that the student can get additional information about the application, help about its usage or fill a question mark.

The student can also set the simulation by selecting the type of collision, movement speed and filling the input variables about the mass and the velocity of the objects. After the initial setting of the simulation the user can start it, repeat it or stop it.

Output reports serve to get information about the simulation.

2) Activity diagram

Activity diagram for this simulation is shown in the Figure 5.

This diagram is graphical representations of workflows of stepwise activities and actions.

First activity that the user should do is setting the initial conditions, choosing the type of collision, speed of the movement as well as setting the mass and velocity of both objects. After setting the Initial conditions the student can either start the simulation or reset the initial conditions. If the user chooses to start the simulation he has to chose the type of report output from the movements of both objects.

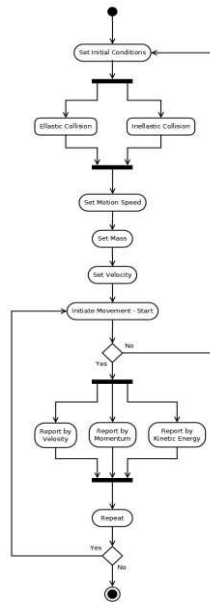


Figure 5. Activity diagram diagram for simulation elastic and inelastic collision

Output report can be divided in three ways, by velocity, by momentum or by kinetic energy. After the simulation ends and the output report is shown, the student can end the simulation, restart the simulation with the same initial conditions or start from the beginning of the simulation.

C. Simulation: Motion with Constant Acceleration

This simulation is designed to describe the physical law of “Motion with Constant

Acceleration” (Figure 6). It shows vehicle moving with constant acceleration. The control panel contains text fields where students can vary the values of initial position, initial velocity and acceleration. By using the buttons at the top of the control panel, students can bring back the car to its initial position or stop and resume the simulation. If students choose the option "Slow motion", the movement will be ten times slower.

Three digital clocks, placed in the working area, indicate the time elapsed since the start. As soon as the vehicle has reached the blue respectively violet ramp with its front bumper, the corresponding clock will stop. Both ramps are adjustable by dragging the mouse with pressed mouse button.

On the working area are placed two diagrams that illustrate the motion of the vehicle: position x versus time t and velocity v versus time t .

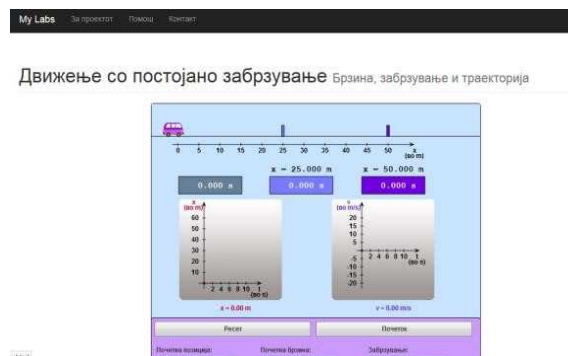


Figure 6. User interface for the motion with constant acceleration lab exercise

1) Use case diagram

Use Case diagram for this simulation is shown in the Figure 7. The student can set the simulation by selecting input variables. After the initial setting of the simulation the user can start it, repeat it, stop it or resume it.

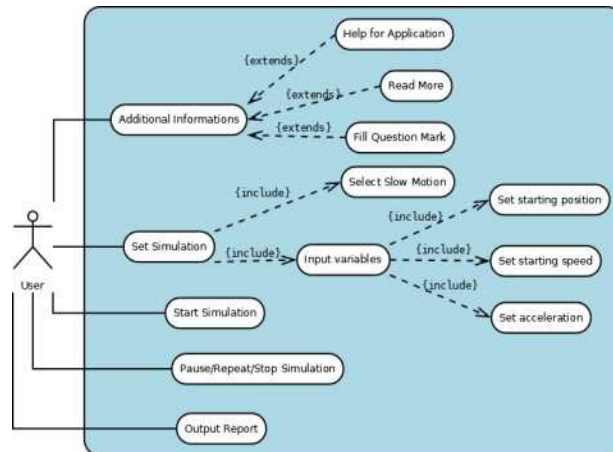


Figure 7. Use case diagram for Motion with Constant Acceleration

Output reports serve to get information about the simulation.

2) Activity diagram

Activity diagram for this simulation is shown in the Figure 8. First activity that the student should do is setting the initial conditions and adjusting the ramps positions.

After setting the Initial conditions the student can either start the simulation or reset the initial conditions. After the simulation is finished, students can read the output values for the time.

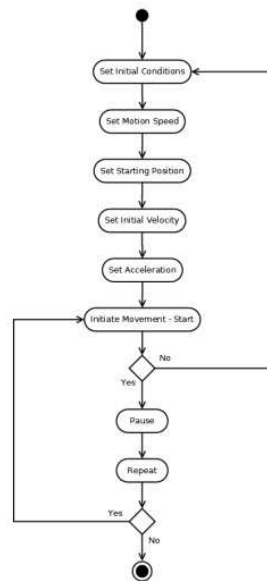


Figure 8. Activity diagram for Motion with Constant Acceleration

D. Simulation: Horizontal Shot

Simulation "Horizontal shot" provides a visual display of a horizontal shot thru a cannon in a field (Figure 9). The work area is located at the top and it contains the animation of the cannon and a ball, placet in a field. The control panel contains the controls for input and output data. Input parameters can be set with a slider control for the speed of the shot and the angle at which the ball should be ejected. The section for output data is presented with text fields and the student may read output values for the position of the shot at a certain time. When the web page with the simulation is loaded, initial condition are set for the speed and the angle. The simulation is started by pressing the "Fire" button. By pressing the "Reset" button, the output results are resetted.

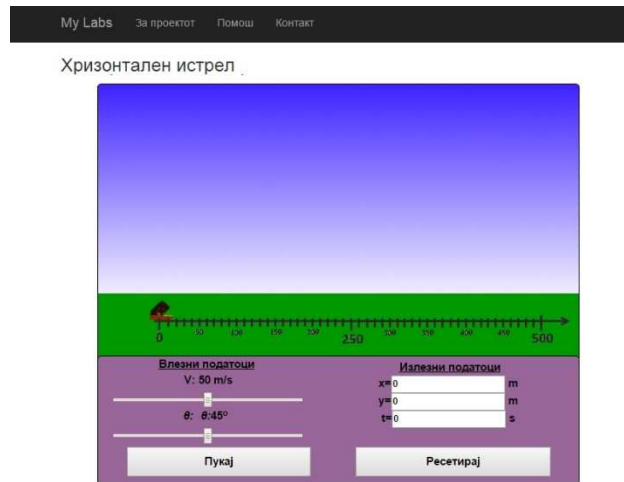


Figure 9. User interface for the horizontal shot lab exercise

1) Activity diagram

Activity diagram is shown in Figure 10. The diagram shows that first activity that the student should do is setting the initial conditions by adjusting the speed and angle, then run the simulation. After the simulation finishes, output parameters for position and time can be read. Once the simulation is completed it can be reset or terminated.

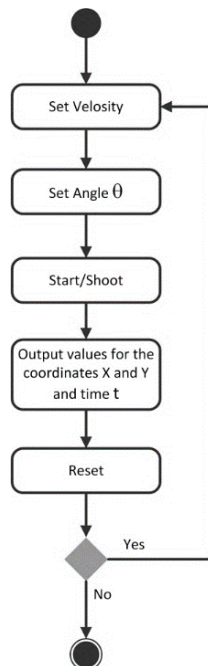


Figure 10. Activity diagram for Horizontal Shot

2) Use case diagram

Use case diagram is shown in th Figure 11.

The student can set the simulation by entering the input parameters. Then the student can begin the simulation. Once the animation is finished student can read the output report or reset outputs. Student also can get more information by choosing one of the additional informations.

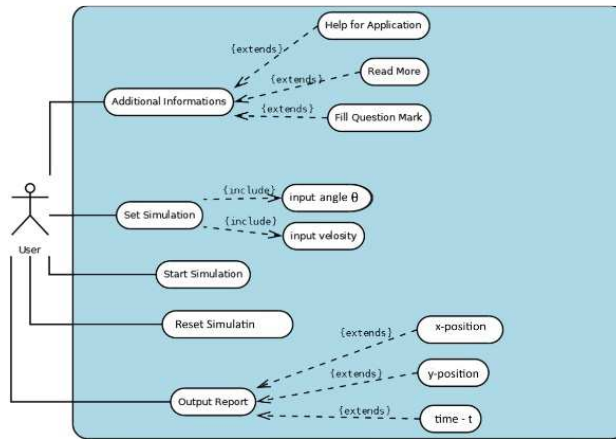


Figure 11. Use case diagram for Horizontal Shot

V. EVALUATION AND RESULTS

The developed virtual laboratory was evaluated by 5 teachers and 100 students from two secondary school students (50 males and 50 females). Half of the students were thought the lessons through the classical way of teaching and the second half were using the developed virtual lab.

The students were chosen in a way that the average grades in both groups were almost the same. The evaluation methodology for students is composed of three phases: the first one is dedicated to system explanation, the second one is aimed at self-learning using theoretical materials which are accompanying each of the lab exercises and experimentation, as well as self-evaluation. The last phase is regarding the evaluation of the acquired knowledge using standard/classic test method and using a survey method. The teachers were asked to answer some questions regarding their personal opinion and observation for virtual laboratory usage. The results from the evaluation are presented in the following.

TABLE I. RESULTS AFTER TESTING

	<i>Group type</i>	<i>Average grade after evaluation (on the scale 1-5)</i>
1	Virtual lab group	4.86
2	Control group	4.11

TABLE II. PERSONAL OPINIONS ABOUT THE VIRTUAL LAB USEFULNESS (AVERAGE ANSWERS ON THE SCALE 1-5)

	<i>Group type</i>	<i>Students</i>	<i>Teachers</i>
1	Do you consider the virtual lab useful?	4.80	5
2	Did you find the virtual lab user friendly?	4.98	5
3	Do you think it could be a possible substitution of the real lab (when the one is missing)?	5	5

VI. CONSLUSION

This paper presents a developed virtual online laboratory that aims at helping high school students in learning physics. It consists of several virtual benches developed as separate fully interactive web modules. The benches were developed to follow the high school curricula of the physics courses in Macedonia. The design and development technologies and system architecture are also presented. The laboratory has been evaluated from both students and teachers perspective and the results obtained are promising.

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PLATFORM FOR TEACHING SOLAR POWERED WIRELESS SENSOR NETWORKS IN UNIVERSITY COURSES

UDK: 371.3:62]:620.91:004.738.5

Original Research

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Abstract: The rapid development of communication and computing technologies significantly affects the importance of Internet of Things (IoT) and its expansion as well. The very important element of Internet of Things is wireless sensor networks (WSN). Those two concepts already have very strong influence on industry. This influence caused growing integration of IoT and WSN topics in the university curricula. Considering that the number of 26 billions of connected intelligent devices is projected for year 2020, the number of newly profiled software developers is hardly to predict. That's why it is very important to include these concepts and their enabling technologies in university curricula. The large percent of predicted 26 billion connected devices will be deployed in outdoor environments and utilized in various scenarios such as smart cities, smart agriculture etc. In the case of outdoor deployment, the autonomous power supply is crucial part of wireless sensor station configuration. In this paper is presented and analyzed the possible approach in using open-source hardware platform in university courses for teaching topics related to solar powered wireless sensor nodes.

Keywords: engineering education, Internet of Things, wireless sensor networks, solar energy

I INTRODUCTION

The two computing concepts have important place in modern era in last several years. Those two concepts are IoT (Internet of Things) [1,2,3] and WSN (Wireless Sensor Networks) [4,5]. IoT represents the environment with networked physical objects or “things”, embedded systems with software, sensors and communication devices. All these objects can collect and exchange data, making possible variety of scenarios such as smart cities, smart enterprise, smart home, smart environment, smart wearables etc.

There are several estimations concerning the number of possible IoT and connected devices in the future. These predictions range from 25 to 50 billion of devices until 2020. According to the Gartner's prognosis in 2020 will be around 26 billion of intelligent devices in the world [6]. The growth of IoT devices is presented in the figure (Fig. 1). Considering the variety of possible usage scenarios such as smart cities, pollution monitoring, smart agriculture etc, the large number of projected wireless sensor stations will be deployed outside in outdoor locations. That makes the question of their autonomous and most efficient power supply extremely important. In order to avoid frequent battery changes, and to lower the electricity costs, the orientation towards solar powered wireless stations is justified.

Another important feature of WSN and IoT is possible usage of wide range of communication technologies in these systems. The communication technologies such as: IEEE 802.11, IEEE 802.15.4, ZigBee, Bluetooth, Bluetooth Low Energy, proprietary protocols etc, can be used almost equally in WSN and IoT scenarios.

The importance of IoT and WSN led to the deep integration of those two concepts and its supporting technologies in the industry. The large number of vendors has significant market share in this area. Deep establishment of those technologies in the industry and expected needs for specially profiled software developers in the future are very important factors in implementation of wireless sensor network technologies in engineering education and university courses.

In this paper is presented the approach of using open-source hardware platform based on Arduino and its clones for usage in university curricula with special focus on solar powered sensor stations. The major focus is given to the description of the components of the platforms with the brief analyses of the

experience with its experimental usage. This paper is continuance and extension of the research published in the paper presented in [7], where the focus is analyses of possible usage of open-source hardware platforms in academic research. The main contribution of this paper is focused on proposal of the efficient platform to be used at universities courses for engineering education.

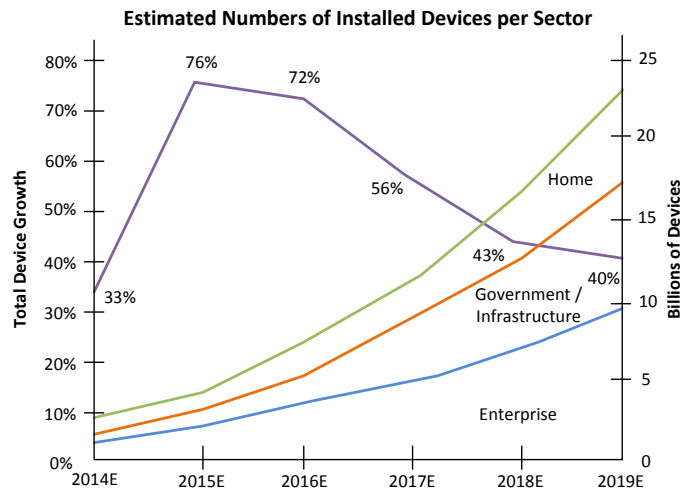


Figure 1. Estimated number of installed IoT devices in the World until 2019 [8]

The paper is structured as follows: after the introduction, in the second chapter are presented two platforms with their main components, together with the open-hardware principles. In the third chapter are presented possible usage scenarios of the proposed platforms. The conclusion and the further work are given in the last chapter.

II PLATFORM BUILT ON OPEN-SOURCE HARDWARE

A *Open-source hardware*

According to the Open Source Hardware (OSHW) Statement of Principles 1.0 [9] - open source hardware is hardware whose design is made publicly available so that anyone can study, modify, distribute, make, and sell the design or hardware based on that design. The hardware's source, the design from which it is made, is available in the preferred format for making modifications to it. Ideally, open source hardware uses readily-available components and materials, standard processes, open infrastructure, unrestricted content, and open-source design tools to maximize the ability of individuals to make and use hardware. Open source hardware gives people the freedom to control their technology while sharing knowledge and encouraging commerce through the open exchange of designs.

Generally, this approach in defining the open-source hardware principles established large market with compatible and low-cost products. These principles also made those components more available and provided the development of small electronic devices, especially in the field of IoT, accessible to everyone. In a way, open-source hardware principles powered up the development and expansion of IoT.

B. *Solar powered Wireless Sensor Network platform*

Two platforms presented in this research are build upon the Arduino Uno microcontroller board [10,11] and its variants. The components of the first platform are presented in Table 1 and on Fig. 2. The basic component of the platform is Arduino UNO. Arduino UNO is a microcontroller board based on the Atmel ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, etc. It is one of the most popular microcontroller open-source platforms in the world. Considering its open design, there are varieties of clone boards or similar boards of other producers that are available on the market. Due its wide popularity and number of variants it is hard to estimate the number of items sold in the world up to date. A number of researches related to usage of this platform in academy courses are made at our institution [12,13,22] as well as on the other academic institution all over the world [14,15,16].

Table 1. Platform No.1 for solar powered wireless sensor station

No.	Item No.	Description
1	Arduino UNO Rev 3	Microcontroller board based on Atmel AT386
2	Solar Charger Shield v2.2	Expansion module designed to enable power from various batteries that has the voltage of 3.0V-4.2V to shift up for 5V output needed for Arduino, or to be used in combination with Li-ion battery and solar panel to form an autonomous sensor unit.
3	Solar panel	1.5W solar panel with dimensions 81x137mm
4	1050mAh LiPo Battery	Polymer Lithium Ion battery 1050mAh
5	XBee shield	Expansion module for Arduino designed for mounting communication modules based on Bee socket
6	XBee S1	Communication module designed for IEEE 802.15.4 protocol
7	Temperature and humidity sensor	DHT22

The solar charger shield is a stackable expansion board that enables battery power to the Arduino UNO. It allows usage of various batteries with voltage from 3.0V to 4.2V to shift it up for 5V output needed to Arduino. This shield is also designed to be used in combination with Li-ion battery and solar panel to form an autonomous sensor unit. The maximum current provided by the board can get up to 600mA which is more than enough for all Arduino configurations and three times more than the power consumption of the presented sensor station. A micro USB connector, on the shield, is also useful to charge the battery connected directly to the PC via USB cable.

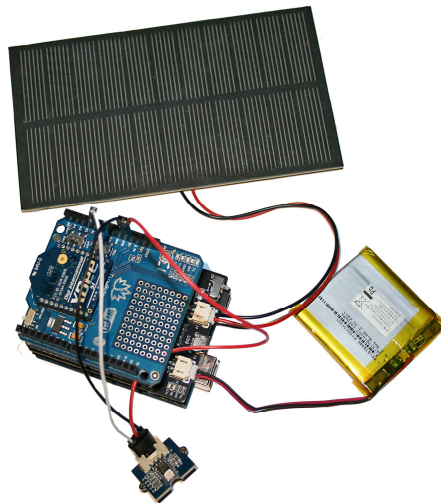


Figure 2. The solar powered wireless sensor platform no.1 based on Arduino UNO Rev3, XBee shield and Solar Charger shield

Solar charger shield in this example is used in combination with the 1.5W solar panel with dimension 81 x 137mm. Solar panel is attached to the shield with 2-pin JST 2.0 PH connector. The solar panel supplies Arduino Uno and charges battery attached to the same board. The attached battery has smaller capacity – 1050mAh and it is polymer Li-on battery. With the two LEDs on the board it can be seen if the battery is charged (red light) or if the battery is full (green light). With above components the autonomous power supply is provided, but the sensor station still lacks the communication and sensing capabilities.

In order to make this station outdoor sensor node, this station needs communication module and sensor. The module used for communication is Digi International Inc. XBee® Series 1 that uses IEEE 802.15.4 technology. This module allows data rates up to 250 kbps and supports network topologies such as: point-to-point, point-to-multipoint & peer-to-peer. The modules can be set to two types: Coordinator (central device) or End device (peripheral). One of the major advantages of using Arduino UNO and clone platforms is its modularity. These platforms are made for DIY (Do It Yourself) electronics and prototyping. So, they are made to build up components by stacking them, using their pins and headers without need to solder them. The all presented components are solder-less. So, the communication for the presented station is not limited to IEEE 802.15.4 technology at all. The platform allows usage of any communication modules using widely accepted Bee socket standard. This standard has 2 rows of 10 pins sockets with 2mm distance in the bottom side of the module. In that way any module with Bee socket is easy to be mounted on XBee shield and to be used for wireless sensor station data transfer. The list of

possible modules, with its main characteristics such as technology and protocol used, range, and operating frequency is given in Table 2.

Table 2. List of variety of communication modules available for the platform

Model	Protocol	Frequency	Range*	Data rate
Seedstudio® MeshBee	ZigBee Pro	2.4 GHz	30 m* / 100 m**	250 Kbps
Seedstudio® RFBee	Proprietary	868 MHz	50 m* / 120 m**	76 Kbps
XBee® S1	IEEE 802.15.4	2.4 GHz	30 m* / 90 m**	250 Kbps
XBee® S1 Pro	IEEE 802.15.4	2.4 GHz	1.6 km**	250 Kbps
XBee® S2	Zigbee Pro	2.4 GHz	120 m**	250 Kbps
XBee® S2 Pro	Zigbee Pro	2.4 GHz	1600 m**	250 Kbps
Seedstudio® BLE Bee	Blue Tooth Low Energy	2.4 GHz	30 m**	
DFRobot BLE Link	Blue Tooth Low Energy	2.4 GHz	60 m**	≤ 1 Mbps
RN42-XV Bluetooth	Bluetooth	2.4 GHz	100 m**	240 Kbps
Bluetooth Bee	Bluetooth	2.4 GHz	20-30 m**	1 Mbps
XRF wireless RF radio	Proprietary	868 MHz	300 m**	250 Kbps
Libelium LoRa SX1272	Proprietary	868 MHz	21 km**	N / A
XBee-868	Proprietary	868 MHz	550 m* / 16-40 km**	24 Kbps
XBee-900	Proprietary	900 MHz	3-10 km**	≤ 230 Kbps
XBee-XSC	Proprietary	900 MHz	610 m* / 14-45 km**	10-20 Kbps
XBee WiFi - PCB Antenna	IEEE 802.11 b/g/n	2.4 GHz	-	1-72 Mbps
RN-XV WiFly Wire Ant.	IEEE 802.11 b/g	2.4 GHz	-	1-54 Mbps

* indoor/urban

** outdoor line-of-sight

The second variant of the platform is built upon Seeeduino Stalker v3 (Fig.3), the microcontroller board based on Atmel ATmega328 with integrated Bee socket and solar charger capabilities. The difference of this platform is that solar and XBee shield are integrated on the single board making it easier to handle.

The communication module which is included in the second platform is Bee socket based module Seedstudio® MeshBee [17,18]. MeshBee is a 2.4 GHz wireless ZigBee RF module. It uses microchip JN516x from NXP that enables several different standards-based ZigBee mesh networking [19,20]. It supports ZigBee Pro stack. It has indoor/urban range up to 30m and outdoor line-of-sight range up to 100m. Its receive sensitivity is -95dBm, working frequency is 2.4GHz and it operates at following data transmission rate: 4800, 9600, 19200, 38400, 57600 and 115200 bps. It has socket compatibility with well known Digi International XBee communication modules [4,21] (2 x 10-pin sockets). Its connectivity with Arduino solar platform is possible with Tinysine XBee shield v2 or similar shield or it can be directly connected to Seeeduino Stalker v3.

The Seedstudio Mesh® Bee communication module on this solar station is configured as Router [4] and it has wireless communication with central network module with a role of Coordinator [4] attached to PC. This configuration with one Coordinator and one Router is needed in order to establish ZigBee network or ZigBee PAN. In this way, solar powered station transmits sensor collected data to the central communication module attached to the application server. The components of the platform are presented in Table 3 and Fig. 3.

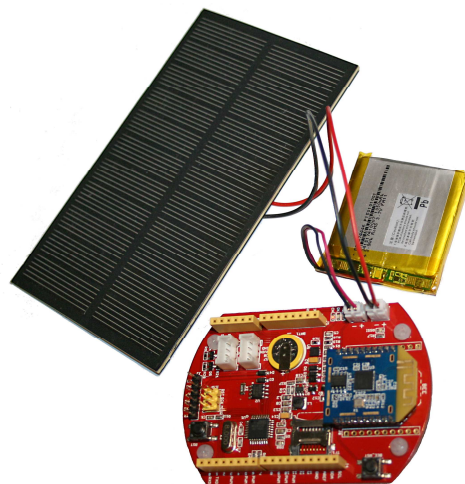


Figure 3. The solar powered platform based on Seeeduino Stalker v3

Table 3. Platform No.2 for solar powered wireless sensor station

No.	Item No.	Description
1	Seeeduino Stalker v3	Microcontroller board based on Atmel ATmega328 with integrated Bee socket
2	Solar panel	1.5W solar panel with dimensions 81x137mm
3	1050mAh LiPo Battery	Polymer Lithium Ion battery 1050mAh
4	Mesh Bee	Communication module designed for ZigBee protocol
5	Temperature and humidity sensor	DHT22

In order to make the sensor stations out of both these platforms, at least one sensor should be used. In this particular scenario is used digital temperature and humidity sensor – DHT22. This sensor collects the data and station send its every 10 seconds to central communication device (ZigBee or IEEE 892.15.4) directly attached to PC (Fig. 4). The time period is determined with the program uploaded to the station. On a PC is installed simple prototype application for collecting data with logging the received temperature and humidity values together with the codename of the sending station, data and time of the data retrieval. Application server can collect data from one or much more nodes with potential ability to store, analyze, visualize data and makes reports on requests. Developed application can monitor certain conditions; make notifications or some other tasks depending of the environment and its purpose. The scenarios of the usage will be presented in details in next section and on Fig. 4 and Fig. 5.

III USAGE SCENARIOS

In Fig 4 is presented one scenario for deploying proposed platforms. Wireless sensor station deployed remotely from the central site, mostly outdoor, collects sensor data. Collected data are sent via supported communication technology (for those two platforms used technology is ZigBee and IEEE 802.15.4) to the central node. The application server hosts the application for data acquisition, storage, visualization and reporting.

The presented platforms can be used in two presented scenarios. First scenario is presented on Fig. 4 where only one sensor node is deployed. This scenario has point-to-point network consisting of one central and one peripheral node.

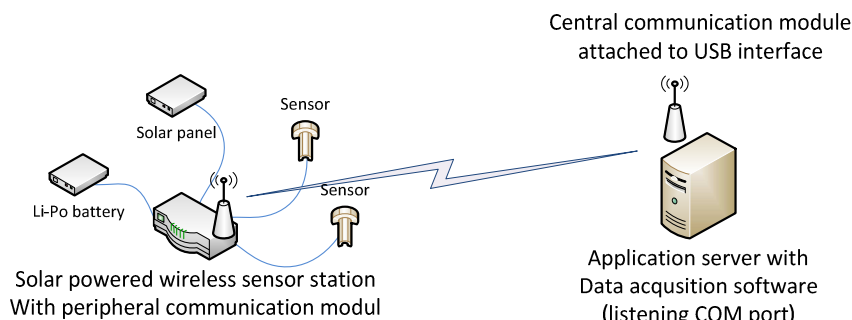


Figure 4. Single node scenario with solar powered wireless sensor station

Second scenario (Fig. 5) is built in star network topology or in point-to-multipoint network. All modules listed in Table 2, support this network topology. In this scenario, several peripheral nodes communicate with one central node. Only ZigBee technology allows creation of more complex structures, with usage of Mesh network topologies. Mesh topologies are not presented in the figures.

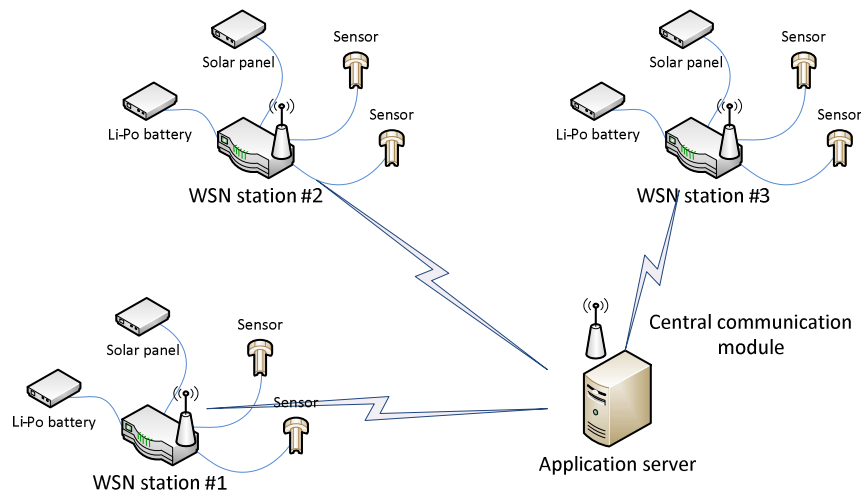


Figure 5 Network made with multiple solar powered wireless sensor station

The presented platforms and scenarios can be used in several ways in university curricula. This paper is made as a part of the research dealing with integration of IoT and WSN technologies in university curricula and engineering education at the institution where the research is performed. This institution, among the other profiles, has department of Information Technology, department of Mechanical Engineering and department of Environmental Protection Engineering. The possible usage models are highly adjusted to the curricula of those three departments and can be classified as:

- *Learning wireless sensor network and IoT technologies* – using presented platforms, students can learn how to program wireless sensor stations and microcontroller boards, to learn using sensors, to learn configuration of wireless communication modules and to learn about wireless communication principles using hardware and software analyzing tools. This approaches can studied within existing courses such as: Communication Systems, Computer Networks and Advanced Communications at Information Technology curricula.
- *Developing applications for WSN and IoT environments* – using presented platforms, student can learn to develop application for the specific WSN and IoT environments. In the specific condition, student can work on developing application for data acquisition, data modelling from various sources, data storage, analyses, visualization and reporting. These approaches can be studied within existing courses such as: Programming and Software Engineering at Information Technology and Software Engineering curricula.
- *To learn basic principles of solar powered devices* – Student can work with solar power technology and can analyze solar equipment behavior in various conditions, energy efficiency, optimal solar utilization within courses of Alternative energy sources at Environmental Protection Engineering and courses of Thermodynamics with Thermo-technique and Energy efficiency at Mechanical Engineering.

IV CONCLUSION

The goal of this paper was to show the possibilities of using the open-source hardware in academic institution for teaching topics related to solar powered wireless sensor stations in IoT environments. The platforms presented in the second section of the paper are tested for a short time and they worked well during the testing period. The stations were power supplied combining Li-Po battery and solar panel.

In this stage of research, the implementation of the presented platforms in laboratory exercises is not made. Proposed platform is assembled, programmed and tested by the researchers. The behaviors of the platforms together with the potential models of platform usage in classroom are analyzed. The reason why the proposed platform are not used in the learning process in order to evaluate the student responses is that only one set of the each proposed platform is currently available. So, the experiments involving the students should be part of the further research and start in following way. First, one or two groups of students can use these devices to work on their projects, bachelor thesis or master thesis. After finished work, student will give their feedback of the platform usability and efficiency. If the general opinions are positive this will give green light for the second phase and further integrations of proposed platform in greater numbers in student exercises.

Moreover, considering that Arduino platform is specially designed for DIY (Do It Yourself) electronics and prototyping, the testing of these devices showed that Arduino based platforms are easy to understand, easy to configure and easy to assemble. All this, make these platforms low-cost and highly efficient tools for teaching and learning emerging technology at multidisciplinary fields. This platform can be used for teaching diverse profiles of engineers such as: Mechanical, Environmental, Information Technology and Software engineers. This diversity makes the platform's unique and major strength in engineering education appliance.

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ASSOCIATION RULES IN DETECTING USERS' BEHAVIOUR PATTERNS IN ONLINE ENVIRONMENTS

UDK: 37.018.43:004.738.5
Original Research

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Abstract – The paper presents the application of association rules in detecting users' behaviour patterns in online environments. The research was done within Moodle LMS. Results show the significance of data mining techniques in the organization of teaching.

Keywords: association rules, behaviour patterns, e-learning

I. INTRODUCTION

Data growth in certain processes brings forth the need for the data analysis and detecting behaviour patterns. General solution for this problem is data mining techniques. According to [1], data mining presents detecting useful patterns of behaviour or connections in large amount of data.

Association rules introduce one of the techniques for detecting behaviour patterns, which is most frequently applied in shopping. The task of the association in data mining is to set rules in data basis. The association is known as the analysis of consumer basket and it is aimed to detect rules according to which the links between two attributes are created. The association does not contain any in advance defined output attributes, but every attribute can be both the cause and the effect of the revealed rule. The principle of the association is: IF attributeA THEN attributeB, and the significance of the rule is determined on the basis of Support and Confidence. The Support is proportional part of the sample members who satisfy certain rule (No. of satisfying members/total No. of members), whereas the Confidence shows the proportion of the members who possess both attributeA and attributeB.

In this paper the association rules are used for determining useful behaviour patterns in the domain of e-learning. At universities, it is the learning management system (LMS) that has been most frequently used in the last decade. This system provides numerous possibilities for organization of teaching through various forms of lessons, tests and collaborative modules (forum, wiki, chat).

There have also been numerous researches regarding the application of rule association in the problems of e-learning.

According to [2], the focus is on is the possibility of successful application of association rules mining in research problems related to e-learning. In this research, the previously mentioned model has been used to show rare association rules when gathering student usage data from a Moodle system. The relevant results have been presented in the comparison among several frequent and rare association rule mining algorithms.

Furthermore, the authors in [3] suggest the application of association rules in the environments for e-learning through descriptive examples and the conclusions arising from them.

Research specificity presented in [4] is related to the new approach of pre-processing data, so that the association rules can be appropriately applied. The mentioned research is aimed to analyse users' behaviour, provide help in learning evaluation and improve the structure of SCORM content.

II. RESEARCH METHODOLOGY

A. *Participants*

Research participants are students of Faculty of Technical Sciences Čačak who are also the users of Moodle system for managing e-learning. Currently, the number of active users is approximately 2000, whereas the LMS (Learning Moodle System) approximately covers 150 courses.

B. *Research Objective*

Research objective refers to determining the possibility for the application of rule association in the problems of e-learning. In addition to this, the research objective relates to establishing connections between the modules and course activities.

The modules imply individual possibilities provided by LMS and available to users. An example for this can be forum, lesson, wiki...

Activities include the actions that users perform, for example viewing, editing, deleting...

C. *Research Tasks*

The research has been conducted through particular tasks which enable the realization of the set objectives.

The research tasks are as follows:

- Data Collection
- Data Selection
- Creation of '*association rules*' model
- Analysis
- Discussion of the results

III. RESEARCH RESULTS AND DISCUSSION

The research results have been shown in the previously mentioned tasks.

A. *Data Collection*

The data have been collected from the server on which the Moodle learning management system is located. Moodle LMS provides the possibility to export records regarding the users' activities in many formats. The following format .csv has been selected.

B. *Data Selection*

Taking into consideration the number of the created electronic courses on the Moodle platform (itlab.ftn.kg.ac.rs), all courses besides the courses intended for entrance exam preparation and degree finals have been selected.

C. *Model creation, evaluation and testing*

In this paper we used the association rules technique. The model was created and evaluated in Microsoft Visual Studio 2010 [5] environment, but it was tested within Microsoft SQL Server Management Studio [6].

Figure 1 shows the structure of '*association rules*' model.

Structure	AS
	Microsoft_Association_Rules
Aktivnost	Input
Broj Studenata	Input
Dan Ime	Input
Godina	Input
Id Kursa	Input
Id Pristup	Key
Mesec	Input
Modul	PredictOnly
Sat	Input

Figure 1: Structure of 'association rules' model

Figure 1 shows the structure and the name of the model (AS). As far as the structure is concerned, the list of attributes is available, as well as the view of input, output and the attribute being predicted. In this research, the module is the attribute which is being predicted.

Evaluation of the created model has been performed through lift chart.

Lift chart measures the model efficiency calculating the difference between the results obtained with the aid of the model and without the model. The results obtained without the model are based on randomly selected records. Lift chart is used for graphic representation of the improvement provided by 'analysis data' model. The graph represents the comparison of prediction accuracy among all models, in order to determine general prediction accuracy, or prediction accuracy for a particular value. Result comparison in the lift chart for various models brings about additional information regarding the type of the model best for specific research problem.

Figure 2 presents the main parts of lift chart.

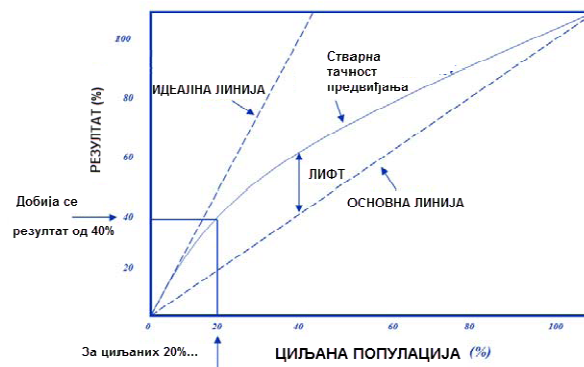


Figure 2. Main parts of lift chart [7]

According to the shown example, the principal line presents the prediction in the random sample in which i.e. in the sample of 20% of population the achieved result is 20%. This result relates to typical return data obtained without the application of any data analysis model, and based on the presented example 1. The presented chart presupposes that certain target value was set. Model evaluation is performed and the improvement provided by data mining model for a specific value is presented for the target value.

Figure 3 presents the lift chart for the performed research.

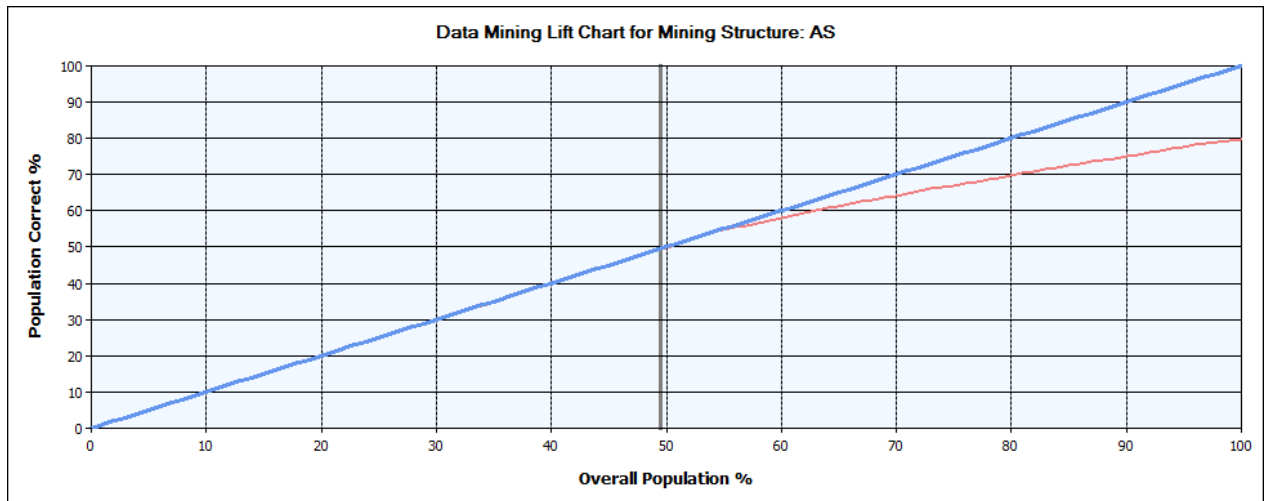


Figure 3. Lift char

In the previously mentioned type of chart (without aimed value of the output attribute) principal line does not exist. Nevertheless, the ideal line and the line regarding the created model are displayed.

In Figure 3, the ideal line is marked with blue colour, while red denotes actual accuracy of prediction. Legend was given in the separate part (Figure 4), according to which the accuracy of the created model can be analysed.

Series, Model	Score	Population correct
AS	0.91	49.98%
Ideal Model		50.00%

Figure 4. Legend for analysis of accuracy

According to the results from the presented table, the following can be concluded: out of 50% of the total tested population, 49,98% is accurately predicted by the created data mining model. Considering the fact that the ideal model of 50% of population predicts 50% of the cases, the created model has deviation of 0.02% from the ideal, thus it can be considered very accurate.

Vertical line in the chart is on 50%, as well as the results in legend for the analysis of accuracy. The vertical line can be moved causing the change in legend results. In this research, the results have been presented for 50% of population. As described in Example 1 (target group for campaign conducting), in this case of 50%, we can reduce cost and choose a part of the sample. By applying data mining model, a significant improvement can be achieved in comparison with random module selection.

Testing of the models has been conducted within Microsoft Visual Studio and Microsoft SQL Server Management Studio.

Figure 5 and Figure 6 show some of the results from the environment Microsoft Visual Studio.

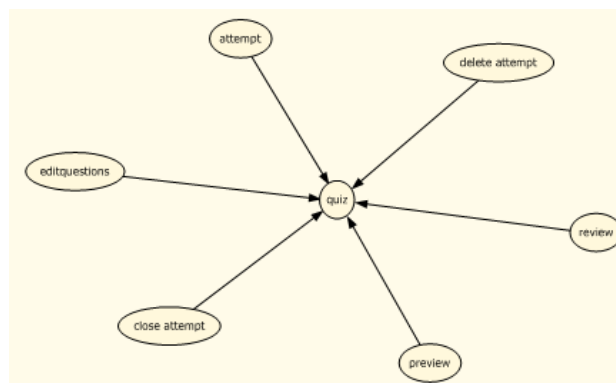


Figure 5. View of connection between modules and activities

Figure 5 presents the connection between each of the module and possible/probable activities. Figure 6 gives insight into individual cases. A group of items in a case is called an itemset. An association model

consists of a series of itemsets and the rules that describe how those items are grouped together within the cases. The algorithm identifies the rules which can be used for predicting the future attribute values compared to the modules, depending on the existing ones.

Figure 6 presents some of the obtained results

Probability	Importance	Rule
1.000	2.621	Aktivnost = submit, Dan Ime = sreda -> Modul = questionnaire
1.000	2.612	Aktivnost = submit, Id Kursa = 84 - 111 -> Modul = questionnaire
1.000	2.624	Aktivnost = submit, Mesec >= 10 -> Modul = questionnaire
1.000	2.616	Aktivnost = submit, Sat = 14 - 18 -> Modul = questionnaire
1.000	2.618	Aktivnost = submit, Mesec < 4 -> Modul = questionnaire
1.000	2.616	Aktivnost = submit, Sat = 10 - 14 -> Modul = questionnaire
1.000	2.623	Aktivnost = submit, Sat >= 18 -> Modul = questionnaire
1.000	2.648	Aktivnost = submit, Id Kursa = 22 - 84 -> Modul = questionnaire
1.000	2.668	Aktivnost = submit, Godina = 2011 - 2013 -> Modul = questionnaire
1.000	2.366	Aktivnost = add contact -> Modul = message
1.000	2.325	Aktivnost = add contact, Dan Ime = petak -> Modul = message
1.000	2.329	Aktivnost = add contact, Sat = 7 - 10 -> Modul = message
1.000	2.332	Aktivnost = add contact, Dan Ime = ponedjeljak -> Modul = message
1.000	2.329	Aktivnost = add contact. Dan Ime = utorak -> Modul = message

Figure 6. View of rules, probability and importance

Besides some of the rules, Figure 6 shows the importance and probability.

For example, for the rule Activity=submit, DayName=Wednesday-> Module=questionnaire, probability is 100%, and the importance is 2.621.

The importance is designed to measure the usefulness of a rule. Although the probability that a rule will occur may be high, the usefulness of the rule may in itself be insignificant. The importance column addresses this. The greater the importance, the more important the rule is.

In addition to the aforementioned types of testing models in this research we used DMX (Data Mining Extensions) queries. They are written and executed in an environment of Microsoft SQL Server Management Studio. The following are example of query and result.

```
SELECT
    [Modul],
    PredictProbability([Modul])
FROM [AS]
NATURAL PREDICTION JOIN
(SELECT "view" AS [Aktivnost],
    "sreda" AS [Dan Ime],
    "5" AS [Mesec]) AS t
```

In this query is shown the use of the function Predictprobability, along with the selected input parameters. As input parameters are chosen the values of activity, day and month.

The result show that forum is module which has the most probability for selected input parameters. The value of probability which gave this query is 95.67 % .

IV. WEB BASED APPLICATION

Bearing in mind the need for Web-based applications the results are integrated and presented thus. The application was developed in the .NET programming environment. Here was used the program language C #.

The application is connected to the Microsoft SQL service for analysis through ADO.NET. ADO.NET is an environment of Microsoft.NET that enables communication with Microsoft SQL services for analysis.

Figure 7 shows the application architecture.

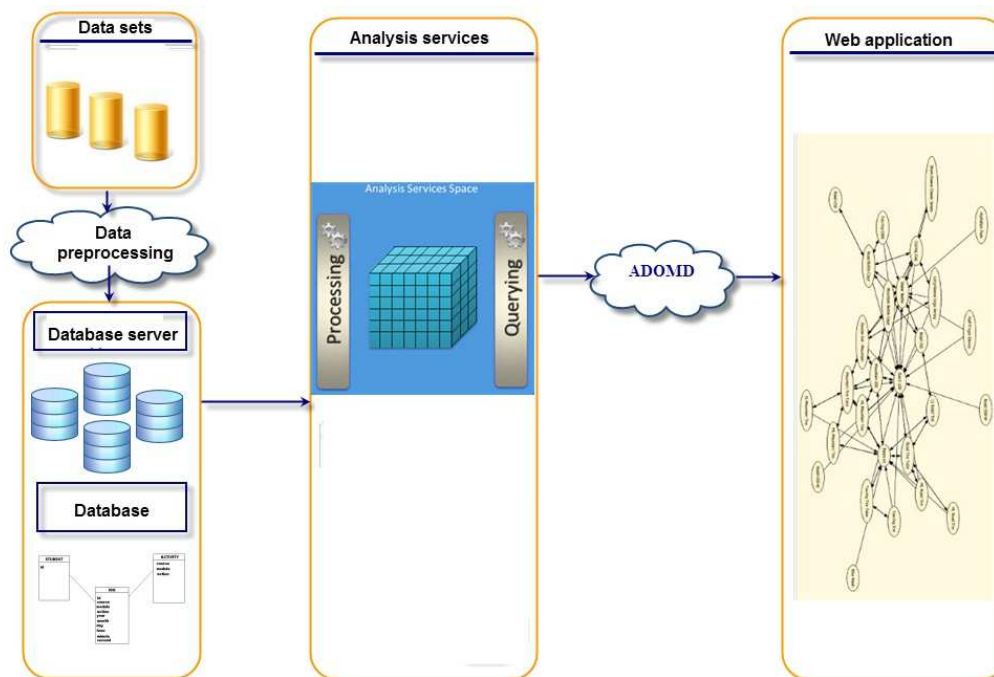


Figure 7. Architecture of the system [8]

After creating a system architecture we created user interface. In the process of creating a user interface must be taken into account that the interface is adapted to final beneficiaries. The end user is a teacher who can teach a variety of subjects and at the same time have only basic knowledge and skills in information technology.

Figure 8 shows the user interface.

For predicting apricots' yealds you should provide input values for given attributes.

Activity

Course

Year

Month

Day

Hour

Minute

Figure 8. Graphical user interface

V. CONCLUSION

Taking into consideration the obtained results, we can draw conclusions on the possibilities of the application of association rule mining in the problems of e-learning. The results reveal the link between modules and activities and they give rules with individual attribute values. Future work regards creating the related mining models for predicting future patterns of users' behaviour.

ACKNOWLEDGEMENT

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ICT IN EDUCATION BETWEEN SERBIA AND SLOVENIA

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Review Scientific Paper

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Abstract: Cooperation today is on a global scale and anyone is welcomed to participate. Global standard in education means that ICT becomes backbone of the education infrastructure and incorporated to the educational paradigm. Europe dictates that student and teacher mobility is almost mandatory. Our intention was to see the difference between two countries that should start using their ICT in education concurrently. With the historical overview, contemporary research on comparison of study programs, and students' opinion we provide the comparison that shows potential for cooperation and mobility. Today's students are digital native in both country and in the article we are present the differences through their views and opinions. We constraint our research on students of educational study programs in three universities in Slovenia and one in Serbia.

Keywords: ICT, education, university study programs, special didactics, student survey

I. INTRODUCTION

ICT in education is the driving force to change curricula at all levels of education. New generations grow with it and use them on a daily basis. These generations, one defined as "*digital natives*", are now more "*always on*" generation. Whoever lectures the students know that students who supposed to listen the lecturer are actually always present on their social networks. Their ability to check the validity of the knowledge they get is instant.

New generation of student require better learning materials. Books are fine but too time consuming. The changes are constant and all present. Though we have introduced ICT in education of teachers in the previous century [1] it is still evident that we have not done enough. From the past project reports "Status and trends of application of ICT in Slovenian schools" it is evident that growth of ICT is not self-evident and require funding [2] [3] [4]. But in the last decade we have huge development in e-learning materials production where university level of education was excluded. [5]

It is evident that we need to prepare teachers to this new reality and give them instruction how to use and prepare their didactically suited and aesthetically pleased learning materials [6] [7] [8] [9] and according to their study discipline [10].

II. HISTORICAL OVERVIEW

The majority of developing countries, among them also former Yugoslavia started the implementation of computers in the educational system relatively late and uncontrolled. The process of implementation only started in the era of microcomputers. Usually it was a centralized system of equipping mostly with imported computers due to the fact that there was no computer industry of their own for these countries in the early eighties. In Yugoslavia, including Slovenia, programmed courses came into effect in the seventies. [11] Until 1970 computers were too expensive and too, while teachers had to make their own teaching materials, sadly without the wanted effect and result. As a consequence there was a minor usage of computers in schools. [12] In every educational institution following the SFRY there was only a few qualified teachers able to teach ICT and computer technology and a few of those using computers for their work. [13] [11]

In the time line below, we will expose events that were crucial for the development of computer science and technology in individual areas:

Table 1: Historical presentation of events

1968	First meeting of the Initiative group for the usage of cybernetics in pedagogy in Zagreb.
1970	Joint meeting of representatives of SFRY's Institutes of Education in Čatež.
1970	SLO: Implementation of computer technology as a course in 3 rd and 4 th year of secondary schools.
1971	Federal agreement (document) titled The Suggestion of long-term Modernization of Educational Activities in SFRJ, international conference of innovations in educational technology in Subotica, the annual school of andragogy with a seminar themed by PUK and learning with the help of a computer in Poreč.
1971	First international research center for programmed courses and implementation of computers – Multimedia center of the Referral center of University of Zagreb.
1972	Start of computerization of schools in Slovenia and other republics.
1972	The establishment and operation of Computer center for programmed learning (RCPU) led by Aleksandra Kornhauser.
1974	I. Bratka and V. Rajković write the first textbook titled Introduction into Computer Technology and Collection of Tasks by a group of authors.
1976 – 1979	RCPU is leading and coordinating the project Computer Technology Courses in Guided Education.
1979	SLO: Computer technology becomes a regular subject in 4 year programs of technical schools.

In a period of ten years a lot of events took place that contributed to the development of computer technology, although we have to emphasize that considering the time of the early start of implementation of computer technology as a study course in secondary schools, there are still schools today with no ICT or computer technology courses.

Table 2: Historical presentation of events

1983 -1984	SI Introduction of optional courses, extracurricular activities and supplementary education for teachers in the field of computer technology.
1985	SI: The establishment of a work-group i.e. a computer technology commission led by V. Rajković. Ivan Gerlič was in charge of educating teachers. The objective was to develop a course of computer technology and encourage its usage in Slovenia.
1985	SI: The establishment of the Center for computer technology in education at the Faculty for Pedagogy in Maribor, where the objective was to increase the usage of computers with didactical courses.
1986	An organized and mass implementation of computers in education starts in other republics and countries
1986	SI: COMPUTER IN SCHOOL – designing a politics of equipping Slovenian schools. The first appendix, Computers in School is published within the magazine Upbringing and Education that deals with problems that occur with the usage of a computer, and a book collection Computer Horizons.
1987	SI: The subject of Computer technology in secondary schools is added a chapter of informatics and therefore a new subject arises, Informatics and computer technology – ICT.
1987	Yugoslavian conference titled Computer in Education which conclusions and observations were a basis for further politics and strategy in implementing computers and contemporary informatics technologies into education. There was also a debate of the politics of modernization of educational technology.
1987	SI: Project COMPUTER DAY – intended for all teachers of primary schools and guiding counsellors of Institution of RS of Education.
1987	SI: Implementation of the following projects: CIRCLING CIRCLES, LOGO in primary schools, and MEASUREMENT COMPUTER in secondary schools, ROBOTICS in primary and secondary schools.
1989	SI: Within the project of DUCK-89 (RACEK-89) an action of an organized purchase of computers and publishing of a book collection The Duck's Little Book (containing mostly manuals for educating teachers) is carried out.
1989	SI: A new publication NIT is published – New Informatics Technologies, which substitutes the dropped appendix Computers in School of the magazine Upbringing and Education.
1990	SI: Project DUCK-90 – computers and licensed software is bought by a large number of primary and secondary schools.

In the early nineties the first implementations of projects of unified equipping of secondary schools and HR secondary schools with personal computers have started. It was already known at that time that the action of equipping schools with computers is not a one-time action but a long-term process, which is supposed to develop continuously.

The development of computer industry has picked up speed and it still shows no decline while the hardware is getting even more functional, more powerful and what is most important more financially available to masses. [13]

Following the disintegration of Yugoslavia, Slovenia led a new path of developing computer science and computerization of schools as an independent country. Towards the end of the nineties, Slovenia has moved away from others previously more or less equal Yugoslavian republics and continued to develop for herself, which has gained her advantage over others.

Table 3: Slovenian project for ICT in education

1992	With the project PETRA a process of computerization of the fifth grade of primary school is
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	implemented. Courses such as Slovene, Art and Technology are taught with the help of a computer. Beside that the project brought novelties such as team teaching and learning, team learning for teachers and the development of didactics of ICT.
1994 – 2000	Realization of a six year program Computer literacy - RO – creates opportunities for computerization of schools on the educational as well as on the organizational level. It included all stages of Slovenian education from pre-school to university.
1994	Project SCHOOL TOLAR (ŠOLSKI TOLAR) – enables the creation and implementation of the RO program.
1999-2000	The Institution of RS for Education produces a project of Computerization of subjects. It consists of three projects. PIKA - computerization of educational activities in kindergartens and lower grades of primary school. TIMKO – team learning and team teaching with informatics technology from 5 th to 9 th grade of primary school, in gymnasium and in four year secondary technical education. VESNA – searching for new ideas and fresh incentives of Computerization in kindergartens, primary and secondary schools along with their education within the project's frame.
2001-2003	IKT strategy in Slovenian educational system is based upon the results of the RO program – Computer literacy (Računalniško opismenjevanje). (Čampelj, 2001)

In the time of Yugoslavia the development of computerization was on a different path, for it was slower in Serbia than it was in Slovenia, which has few advantages in this area. The disintegration of Yugoslavia came as a great blow for Serbia because there was a status quo at that time in the field of computerization. After the disintegration there were other factors that impeded the development of computer science.

The reason for Serbia starting to develop the IKT technology later, at the beginning of 21st century was in its long-lasting period of economic and political isolation at the end of 20th century.

Table 4: Serbia's project for ICT in education

1992-1999	The biggest decrease of the development of IKT.
2000 -	Intensive and fast development of the IKT.
2004	Ministry of Education contributes the IKT equipment for more than 2.000 teachers of primary and secondary schools.

Table 5: Internet speed.

	SI		SRB	
	F	f(%)	f	f(%)
from 1 Mbit/s	12	7.74	16	16.67
from 1 Mbit/s to 5 Mbit/s	40	25.81	10	10.42
from 5 Mbit/s to 15 Mbit/s	47	30.32	28	29.17
from 15 Mbit/s to 50 Mbit/s	30	19.35	38	39.58
from 50 Mbit/s to 100 Mbit/s	22	14.19	3	3.13
more than 100 Mbit/s	4	2.58	1	1.04

It is evident from the table that the average data transfer rate from the internet among Slovenian students is at its peak from 5 Mbit/s to 15 Mbit/s (30%), while the average data transfer rate among Serbian students is from 15 Mbit/s to 50Mbit/s (39%), which shows that on average Serbian students have a faster data transfer rate. More Slovenian students found themselves in the ratio from 50 Mbit/s to 100 Mbit/s (14%), while there are only three Serbian students in that level. The results were not expected and they show that infrastructure is not the obstacle to the use of ICT in education. According to the results it can be said that Serbia, especially the area of Vojvodina, has been developing fast in the field of computer science in the last few years.

Table 6: The application of ICT in education within didactical courses.

			Country		Total
			SI	SRB	
Application of ICT	YES	Count	88	42	130
		% within country	45.8%	31.3%	39.9%
	NO	Count	104	92	196
		% within country	54.2%	68.7%	60.1%
Total	Count	192	134	326	
	% within country	100.0%	100.0%	100.0%	

Regarding the Pearson Chi-square test it is evident that there are significant differences between countries ($\chi^2=6.911$, $p= 0.009$). Data also shows that 54% of students of Slovenian universities think ICT is not present enough within the didactical courses Therefore we could not show that Slovenian students have unified opinion about the presence of IKT. In Serbia the difference is more obvious, 68% of students think there is not enough of ICT within their courses. It can be concluded that the ICT is more present in Slovenian study programs but obviously not enough. We believe the result is expected because there is often a lack of interest with the lecturers for improving their own teaching strategies that would require ICT.

Table 7: ICT knowledge between study programs

			Country		Total
			SI	SRB	
ICT knowledge	YES	Count	76	116	192
		% within country	39.6%	85.3%	58.5%
	NO	Count	116	20	136
		% within country	60.4%	14.7%	41.5%
Total		Count	192	136	328
		% within country	100.0%	100.0%	100.0%

The table shows results we have not expected. In Serbia 85% of students claim they get enough information on ICT in their study programs, while Slovenian students are not even near this numbers (39.6%). Statistical differences is significant ($\chi^2=73.743$, $p=0.000$). The result was certainly not expected but we are pleased to see that despite the late development of computer science and introduction of ICT it has extended among study programs. Slovenia has to improve certain areas renovations of study programs with a more ICT inclusion into the curricula.

Table 8: Use of ICT equipment

	SI		SRB	
	F	f(%)	f	f(%)
Computer	188	98.43	129	94.85
Tablet PC	59	30.89	20	14.71
Smartphone	168	87.96	77	56.62
Internet	184	96.34	86	63.24
Video	62	32.46	17	12.50
Sound	35	18.32	8	5.88
Other	2	1.05	0	0.00

Students could chose more options in this research question. Slovenian and Serbian students use computers most of the time (more than 90%). Internet is firmly in the second place and smart phone in the third though Slovenian students show a higher use of those (smart phones). The table shows that Slovenian students are more distributed among the variety of ICT equipment (or services) than the Serbian students. These elements are influenced by a factor of availability to a variety of equipment.

Table 9: Use of ICT equipment among lecturers in classes/practice for special didactics

			Country		Total	
			SI	SRB		
Use_of_ICT_lectures	mostly no	Count	14	1	15	
		% within country	7.4%	0.7%	4.6%	
	rarely	Count	79	122	201	
		% within country	42.0%	89.1%	61.8%	
	often, not	Count	83	13	96	
		% within country	44.1%	9.5%	29.5%	
	always	Count	12	1	13	
		% within country	6.4%	0.7%	4.0%	
	Total		Count	188	137	325
			% within country	100.0%	100.0%	100.0%

Students in Serbia were very critical of their lecturers because 89% of them think their lecturers do not use enough of ICT equipment, while in Slovenia opinions are divided, which causes a significant statistical difference ($\chi^2= 82.597$, $p= 0.000$). In Slovenia 42% of students think the ICT is not used often enough and another 43% think opposite. Regarding that it can be concluded that Serbian students demands more use of IKT equipment among their lecturers, although Slovenian lecturers have a lot to do to reach a satisfying level of everyday use of IKT equipment. The lecturers are the ones that can teach students how to use certain learning strategies in classes because students will not learn them by themselves for it is not systematic and it would take too much time.

Table 10: Use of ICT for study deliverables production.

	SI		SRB	
	F	f (%)	F	f (%)
Web classrooms	88	46.81	22	16.06
e-materials	147	78.19	80	58.39
Web encyclopedias	108	57.45	50	36.50
Specialized data bases	100	53.19	38	27.74
Texts from other educational institutions	98	52.13	89	64.96
Multimedia elements	138	73.40	26	18.98

Student use ICT to make materials needed for their studies. Slovenian students mostly use multimedia elements (73%) and e-materials (78%), interestingly on the last place is the use of web classrooms (46%) despite Moodle is used on every educational institution in Slovenia. In Serbia the most used elements represent texts from other educational institutions and e-materials, while at the last place is also the web classrooms. According to these results we can conclude that students should probably be more informed on the use of those elements and introduce them as a very practical and interesting tool with the production of various works.

Table 11: Respect of copyright materials

			Country		Total
			SI	SRB	
Respect of copyright materials	DA	Count	147	21	168
		% within country	78.6%	15.3%	51.9%
	NE	Count	40	116	156
		% within country	21.4%	84.7%	48.1%
Total	Count	187	137	324	
	% within country	100.0%	100.0%	100.0%	

Due to the fact that students produce many seminar works during the study years and should respect the legal authors' and copyright agreements. The biggest differences among Slovenian and Serbian students have been noticed here as 78% of students think that faculties in Slovenia respect those rights, while 84% of students in Serbia think that their faculties do not have an adequate system for that issue. That caused a significant statistical difference ($\chi^2=137.206$, $p=0.000$). Every faculty needs to respect reserved rights with no exception and therefore a lot of efforts need to be put into solving this issue.

Table 12: uniformity of citation system

			Country		Total
			SI	SRB	
Uniformity of citation	1	Count	169	124	293
		% within country	90.9%	90.5%	90.7%
	2	Count	17	13	30
		% within country	9.1%	9.5%	9.3%
Total	Count	186	137	323	
	% within country	100.0%	100.0%	100.0%	

Different study programs use different citation systems of citing the other work in their deliverables (seminars work, diplomas, master and doctoral thesis). A high percentage of students from Serbia as well as Slovenia, even 90% think that there should be a uniformed citation system, with no statistically significant difference ($\chi^2=0.011$, $p=0.915$) between countries. This shows that a uniformed citation system would solve many issues and avoid inconveniences when students use different citation system for each discipline or even each lecturer. The result was expected because the variety of citation' systems causes many frustration between students. To speculate in that matter a little we do not want only one citation system. But it would be nice to have such standards (e.g. APA, IEEE) which are supported in contemporary Microsoft Word and solve those problems and inconveniences forever.

III. CONCLUSION

Based on the historical review of events and survey, which was conducted in Slovenia and Serbia, we got surprising and unexpected results. According to the data from the 90th where the difference between the two countries was the largest, is now steadily decline. It becomes evident that the use of ICT in education in Slovenia declines as country is gripped in the constant economic crisis. On the other hand Serbia, whose economic situation is no better, slowly and steadily grows. Professors and students must be aware of the importance of ICT whose purpose and use is versatile. On the other hand technology itself is not enough and countries must educate professors to use it. It is also wrong perception that young generation will know how to use ICT efficiently and effectively without any help and instructions. No matter what we do "digital natives" will use the ICT technology in ever greater extent and we ought to be prepared for them.

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