

Preparing advanced Matlab users

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Abstract: This paper is about preparing advanced Matlab users mostly at the Faculty of Electrical Engineering and Information Technology in Bratislava. We described how is our basic course organized and what methodology we use on the course. We show how to improve student's results by focusing on individual work of the students and proper motivation by evaluating finished tasks on practices. We also compare other type of evaluating task. By using modern communication possibilities we show how to interact students to improve the course. Finally we show you student's opinion on our system of teaching, how we interact with others institutes by providing more courses outside the faculty and how we extending our knowledge by participating on Matlab conferences.

Key-Words: Teaching, Matlab, Week tasks, Web materials, Forum, Social network, Colaboration, Open source

1 Introduction

Learning is important and many times lifelong process in our lives. Our society demand from us knowledge and skills to improve quality of our lives, work, society and economy. Education institutes prepare students to fulfill these requirements. There are many modern methods and technologies for learning but most of them have one in common today – computers.

Computer aided learning found way in learning process from primary schools to universities. In fact students search more and more for information on Internet. Study [1] shows that many students consider Internet as great source of information and using it in learning process. Internet is full of e-learning projects, documents, presentations and multimedia content that students may find useful in their learning process. We must be also aware of negative effects of using Internet like listed in the paper [2].

Computers are also significant involved in learning of technology science like mathematics, physics and informatics. Technical computing plays important role in these specializations. Many software applications are accessible for example Matlab, Octave and Mathematica. The broadest world wide spread application from these all is probably Matlab, which is considered as standard in technical computing and science.

Matlab is very powerful tool for computing and simulation. Basic mathematic core provide functions

for high performance. On top of that Matlab provides add-ons (toolboxes) to enhance usage of more functions in specialized fields of technology, economy, medicine or biology. Matlab is also involved in many publications in different field for example:

- Image processing [3]
- Control [4, 5]
- Power systems [6, 7]
- Real-Time [8]
- Finance [9]
- Others

Matlab is not only exploited in computations but also in learning process. In Matlab environment small GUI applications can be created to improve learning [10, 11].

Learning process is often high cost. Students like to use free resources. Free software and open source application are the one of the solutions [12]. Free resources on Internet are obvious for them.

Students have different types learning capabilities. We can't satisfy all of them, but we could motivate them to give the best performance possible. One of the proper motivator is their evaluation. If students can see that hard effort is rewarded, they want to learn more and more. Other motivator is collaboration [13]. Many students are competitive by nature and they want to give better performance than others. On the other hand collaboration can

help them solve problems that they are stuck with hours or days. Therefore collaborative learning is very important for them because students try to work in team.

In this paper we describe Matlab course at the Faculty of Electrical Engineering and Information Technology Bratislava, how we motivate our students by evaluating tasks and how we collaborate all with each other. The paper is divided into few sections. In the second section we briefly describe our faculty. The third section is about Matlab course, lectures and exercises. In the fourth section we show our materials and interaction between each others. The fifth section is about task evaluation and the sixth about student's results. The seventh section shows how we extend our knowledge by participating at the Matlab conferences.

2 The Faculty and Institute

The Faculty of Electrical Engineering and Information Technology is one of the seven faculties of the Slovak University of Technology, the oldest and largest university of technology in Slovakia. The Faculty was founded in 1941. Since that time, the increasing progress in electrical engineering and information technology has been mirrored by an increase in size and diversity of its research involvement and teaching.

Since 1993, the Faculty has established a new system of university study, conceived in terms of European trends of university education development. It is a three-stage system of study, fully compatible with the terms of the Bologna declaration and with other relevant international documents.



Fig.1 Faculty of Electrical Engineering and Information Technology

One of the departments at the faculty is Institute of Control and Industrial Informatics. Institute is grant in study programs Industrial Informatics (undergraduate program), Cybernetics and Robotics (graduate program). Institute also covers

postgraduate degree. Industrial control engineers needs much knowledge in mathematics, physics to establish mathematical and cybernetics models of controlled processes and systems. They need powerful tools to simulate designed models in different control scenarios. They also need to be experts in modeling and optimization of controller parameters via evolution algorithms. Matlab from The Mathworks has all capabilities to the best tool for all these tasks. Therefore we teach using Matlab for main tasks at the first terms of undergraduate study.

3 Matlab course

Matlab is very powerful tool for technical computing and simulation. It is time saving tool for high performance computations because it is optimized for this kind of tasks. It also supports lack of real word system in education. Matlab contains many add-ons which are very useful in many fields in science. In university environment we use Matlab mainly for these reasons is very popular in many science projects, bachelor, diploma and dissertation thesis. Basic Matlab course was established at the Faculty of Electrical Engineering and Information Technology to learn students use these tools. Matlab is a basic tool for every student in our faculty. For this reason we try to move this course to the first year of study. The knowledge, which students take from this course, is very useful in lot of the other technical courses.

3.1 Matlab

The Matlab high-performance language for technical computing integrates computation, visualization in programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. It allows you to solve many technical computing problems, especially those with matrix and vector formulations, in a fraction the time it would take to write a program in scalar non-interactive language such as C or Fortran. In university environments, it is a standard instructional tool for introductory and advanced courses in mathematics, engineering and science. In industry, Matlab is a tool of choice for high-productivity research, development, and analysis [14].

MATLAB features a family of add-on application specific solutions called toolboxes. Very important to most users of MATLAB, toolboxes allow you to learn and apply specialized technology. Toolboxes

are comprehensive collections of MATLAB functions (M-files) that extend the MATLAB environment to solve particular classes of problems. You can add on toolboxes for signal processing, control systems, neural networks, fuzzy logic, wavelets, simulation, and many other areas [14].

3.2 Lectures

As we mentioned at the Faculty of Electrical Engineering and Information Technology Bratislava is Matlab used in many mathematical and technical courses. Students use Matlab for their computations and solutions in bachelor, diploma or dissertation thesis. It is a part of their all student live.

Matlab course is introductory course to Matlab, Simulink and Matlab toolboxes. The faculty has a two terms per year. Each term has twelve weeks. Course can be taken in second year of study in the second term at the faculty or at second term of first year of undergraduate study. It consists of one lecture (100 minutes) and practice (100 minutes) per week. The lectures aren't compulsory, but practices are.

The number of attendance the lectures is more than half of all students. The lectures are combination of illumination, solving of basic tasks and discussion. All of tasks are solved directly on computer using Matlab. The students can see how to solve the concrete problem and can do the notes to their papers. The full paper of lecture is available a week ahead on the web pages of course. The students can print this paper and do some notes directly to them. The papers with notes are useful source information for the practices. For this reason are usually students who attend the lectures more successful than students who don't have the notes from lectures.

The aim of the Matlab course is to introduce students to the Matlab, to learn them basic principles, syntax and solutions of some common problems. We focus on the most common problems which students may use in their future study or on the others courses. We cover these topics:

- Matlab basics and programming
- Graphics and GUI
- Simulink
- LTI continuous and discrete systems
- Non-linear systems
- Identification
- Fuzzy logic
- Virtual reality
- Stateflow
- Neural networks

- Real-time

As you can see, there are many topics for just one course. But with time that is given to us, we just cover simple introduction to this topics. That is a not big problem because their will have detailed courses for most of the mentioned topics in the future. Main idea is to show them basic principles and solutions that Matlab provide. Then they can extend their knowledge of Matlab course on the other courses. It isn't problem for them, because they have solid basic of Matlab "driving".

3.3 Practices

The practices relate to the lectures. Students are solving some problems related to the theme on actual lecture. Problem is at the first solved verbally and at the board. Students then try to find out solutions in Matlab environment. The similar problems were solved in the lecture by teacher. This is a time for notes from lecture. Practices are set up in the way that students haven't much time to learn the topic on exercise so they have to always come poised.

Every student has his computer and work alone. They can use the computers with Windows or with Linux operating systems. Students can use their own notebooks. These facts improve the environment in the class. Ever student can use operating system, which they want. The Matlab can run on Windows, Linux and Mac OS X too.

There are two lessons which take hour and forty minutes together. Teacher checks and rate every students work about ten minutes before end of the practice. The tasks are to prepare students that they would finished given tasks before hour and half without problem. Many of them in fact do it successfully.

4 Materials and Interaction

Computers really changed our lives and today are almost impossible to imagine life without them. We often use them without knowing it. Computer by itself is really powerful tool for computing, but for many years also for communication and sharing information. In fact, the basic idea for Internet was collaboration across the continent with other researchers. We significantly use this tool today not only for sharing information but also in learning process. E-learning is most popular and modern activity in this process. We are also using web technologies for improving our student's results.

Although possible we do not use any Learning management system (LMS). We are able to use Lotus Learning space as well as Moodle LMSs. Some courses use them but not Matlab course. It is because there is no integration tool for LMS to Matlab and simple loading solutions cannot prove students activity during practices at acceptable level.

4.1 Open source technologies

For some student education can be expensive even if it is for free (like in our country). Reduction of costs is our priority too and we try to be supportive for them. We are trying to work with open source technologies which are comparable to commercial technologies.

Students often own computers for studding purposes. First cost reducer can be operating system. For commercial operating systems like Microsoft Widows or Apple OS X existing alternative free UNIX-based operating systems for example Linux distributions like Red-Hat, SUSE, Ubuntu and many others or BSD variants. We are always prepared to consult their problems and installation of the Matlab or other software on open source systems. We are able in some cases to recommend some free alternatives to used proprietary software. This not usable in every task but it many cases are open source alternatives usable as low cost solution.

The second reducers of cost are office applications. Student uses these applications to write seminar papers, to produce tables, simple pictures, multimedia presentations and many other course outputs. You certainly know Microsoft Office and its open source alternatives for example OpenOffice.org or NeoOffice. OpenOffice.org contains these parts:

- Writer
- Calc
- Impress
- Draw
- Base

You can use Writer for fully equipped word processor, Calc for spreadsheets, Impress for making multimedia presentations, Draw for graphics and diagrams and Base for simple databases. OpenOffice.org forms an ideal teaching platform for core computer literacy skills, without tying students to commercial products. OpenOffice.org is also an ideal platform for creating teaching materials and managing administrative tasks.

Main advantage for OpenOffice.org is that this application works with Open Document Format. Other application that implements this format can read our document without problems so students can choose their popular office application. Open Document Format is also supported from European Commission and it should be implemented in public administration within few years. It is also a part of its public administration recommendation listed on osor.eu during august of year 2010. Open Document Format 1.0 was confirmed as ISO standard number 26300:2006. Version 1.2 of the Open Document Format is part of regular revision of ISO 26300. ODF is used by several proprietary products like Apple iWork, Microsoft Office 2007 Service pack 2 and later. Open source productivity suites as Koffice, GNOME Office as well as Abi Word uses ODF as its main format.

We are also using OpenOffice.org application for making lecture presentations, practices task documents or pointing results in spreadsheet. We also made one observation with presentation making. Students like rich multimedia presentations at lectures but when they want to bring these study materials printed to the lecture then rich multimedia presentation it isn't suitable option. Therefore we used two presentation templates for presentation making and students didn't have to print colorful presentations. Another solution will be to design hands-outs with different template than presentation. Hands-outs can be done by word processor instead of presentation software then. Hand outs could be distributed in non editing ISO standards like Portable Document Format. This is also allowed to be done by OpenOffice.org productivity suite as well and with no complications as they are standard for Microsoft products. Hands out would be prepared in LaTeX as well.

4.2 Web materials

As we mentioned before Internet is great source for information exchange. Modern student's first choice for material search is also Internet at the moment. For this fact we build web page for course to make it easy for them to find materials. On our web page students can find all about the course. They can find contacts to us in case they forgot them, some news for the course and another useful page links. It serves as a part of Moodle LMS. Our web pages are prepared in iWeb software. This is WYSIWYG editor for doing web pages. The advantage of this software is their very gut graphical user interface. It isn't problem add the new lectures and important information for students by several clicks. The

HTML code isn't optimal, but the easy and quick use of this product is main advantage. For this reason is possible often up-date the web page.

Web page is divided in sections. The most wanted sections are about the lectures and exercises. Students can find there lectures and exercises materials in electronic form. Also detailed information about both is there. A few topics has own video tutorials and students could view it at home and be better prepared on the practices. Video tutorials have main advantage. Students can directly see what the teacher is doing and therefore they are easier to understand. Some of the video tutorials are mentioned in references [15, 16]. We would like to publish these free video tutorials in Apple Store iTunesU in the future.

The lectures aren't one source of materials. Students use many different materials at the practices. The main material for Matlab study could be the Matlab reference manual which covers all topics and functions that students can use. Matlab reference manual is also accessible online. Student can search the Matlab topics and functions help without installing Matlab tools.

The practice room is equipped by computers connected to the internet of course. Students can find their problems solutions on the web pages. On our page at which we publish students articles we decided to write small articles about Matlab in Slovak language (also understandable in Czech because these two are very similar because Czech republic and Slovak republic was established on January the 1st via divorcing Czech and Slovak federal republic.). Articles slowly cover the Matlab topics so the students have many tutorials. Beyond the articles discussion to the article is available. The articles come out one or two times per month [17]. We also publish some experiences on our publishing portal named Posterus (www.posterus.sk).

4.3 Matlab forum

Collaborative learning is very interesting area in learning. Student helping each others to better understand some topics. Main advantage of this method is that student didn't stuck and some part of topic that he didn't understand. This is much more times efficient and students can learn much more. This helps collaborative learning type students as well as individual learning type students to achieve better results

To support collaborative learning we founded Matlab forum [18] two years ago. On the forum student can ask any Matlab related questions. It isn't forum just for this course. The questions can be

related to various problems at which students came through on their study in every course and are about Matlab. Most of the questions are answered by us, but there are some others responders that can easily support us when we haven't much time. They include local Matlab software distributor employs.

There were more than six hundred themes and more than twenty seven thousand replays at the time we wrote this paper. The usage of the forum grows beyond our faculty. Now regular daily coming day's students from different faculties around Slovak Republic and Czech Republic come to our forum and ask questions about Matlab. Foreign students are also welcomed as they can ask us in English as well.

4.4 Facebook

Speaking of Internet and collaborative learning we must also mentioned social networking. Social networks are very popular today. Majority of people are at least at one social network. Most favorite social network is Facebook. Like Internet, Facebook also started on academic field. Facebook was founded by Mark Zuckerberg with his college roommates and fellow computer science students Eduardo Saverin, Dustin Moskovitz and Chris Hughes. The website's membership was initially limited by the founders to Harvard university students at Cambridge, Massachusetts, but was expanded to other colleges in the greater Boston area. Now it has more than 500 million active users all around the world.

Facebook enables to create groups. Groups can be created by interests, activities and others topics. We established new facebook group for students of Matlab course last year [19]. This group has 58 active members who are mainly students of our course. We use this group for quick and short information about course. Every member can comment tasks from practices and lectures. It is very useful feedback from students to teachers. Lot of students use this group for publicity their works. They want to show results of their work to other students and share the algorithm. It can be a platform for new projects in the future. It can be also used as a sort of learning management and e-learning system.

5 Tasks evaluation

Student's results are evaluated through assigning points for each course independently at the Faculty of Electrical Engineering and Information

Technology Bratislava. Students can achieve 100 points at most. Most times points are divided into two parts. The first amount of points can student gets on practices or tests through term. The second part they can get on the exam test. In most cases it is 30/70 (practice/exam) or 40/60. Weight is on the exam as we can see. Maximum count of points allowed achieve during terms is 50 for undergraduate courses.

5.1 Week task

There are two main evaluation (or result classification) systems. The first system classifies students via two or three check points through term. So at the end all comes to these tests. Point results depends on how successful are students to answer the test tasks. It is a little bit problem when students doing great at the practices, but they vacillate on the tests at the end of course. They also don't have to learn until test is in sight. This problem had mathematician's long time ago. Students came from high schools and weren't used to learn so much more or they had different knowledge of mathematics. Many of them fail some basics mathematics courses.

Mathematicians try another pointing system that "forces" students to learn more often than just before tests. Student was evaluated on every exercise. On the next exercise they had small test on previous topic. The results of the student grow significantly. We also stick to this schema. We had two reasons for that. One reason was that we had many topics covered in our course. It would be not wise to test student on topics they forget long time. Another was that we want to "force" student to do something more. We choose to give more points during the term, so we give 40 points maximum for practices. There were 10 practices for 4 points, the first and the last weren't evaluated. Student gained about 34 – 40 points. You can see classification distribution on the figure 2.

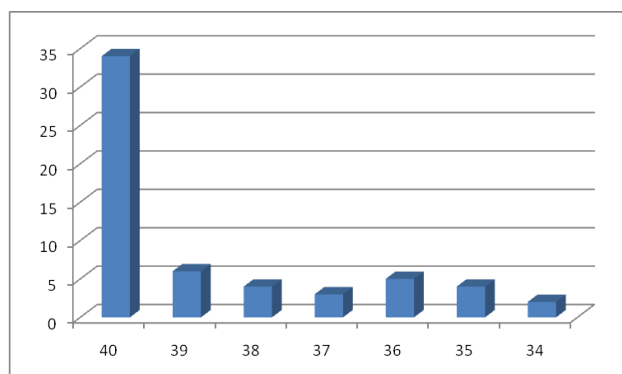


Fig.2 Number of students for points

5.2 Advantages and disadvantages

Every student has different capability to learn. We can't choose unified methodology to learn them all that we know. But with proper motivation they will be willing to learn by them self more within their free time outside the university. Our week task evaluation is kind of motivation factor. Reachable classifications are motivators for being excellent prepared for practices. Now it is time to talk about advantages and disadvantages of our methods. We think of these advantages:

- Students must come educated
- Student are evaluated for what they learned on the lectures last week
- No homework
- Students will also learn work under time limit and stress

Of course every method has some disadvantages. We think of these disadvantages:

- Limited time for educating outside of exercises
- Collision with other courses tests
- Limited time for finishing tasks
- Work under stress
- Problem with student absence on practice (small ability of repeat the same practice)

This method has also some advantages and disadvantages as we can see. The question is if this system works with students. You will see what they say about it in next session.

6. Students opinions and results

In automatic control system there is the most valuable information one that comes from the feedback. Certainly we stick to this concept in our course. We are giving some questions to the students at the end of the term. Some information and feedback we have through Facebook and Matlab forum during the term.

6.1 Questions

Their answers are anonymous. Some of the questions are:

- How do you rate the course difficulty?
- How much do you think you have learned?
- How would you rate lectures?
- How would you rate practices?

- Were the topics explained clearly?
- Do you like the system of work evaluation on every exercise?

The answers depend on individual students, but most of them agreed at some points. The lectures and practices were rated positive too. Explanation was clear, but they want more practical examples. The most interesting part of the questions was the first two questions mentioned. In course difficulty the answers were following:

- very easy
- easy
- normal
- hard
- very hard

Most of the students answered normal or easy. So in the comparison with other courses was Matlab course difficult same or easier. The result of the answer to the first question is depicted in the Fig. 3.

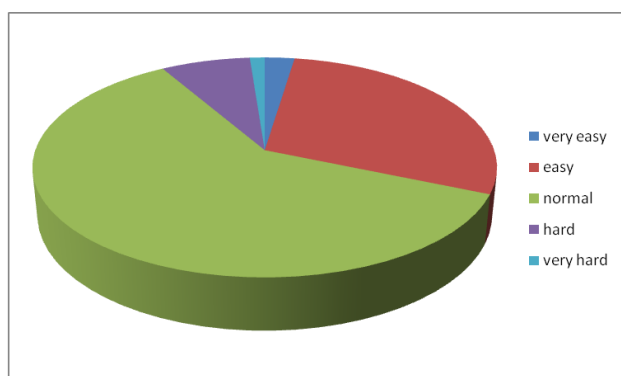


Fig.3 How do you rate the course difficulty?

Equivalently we ask students what they think about how much they have learned or handled. The possibilities were follows:

- very little
- little
- normal
- much
- very much

Students had to learn for every practice, so they subjective evaluation was that they has learned mostly much. But that wasn't only the subjective opinion. Their education classification results show that they were doing well.

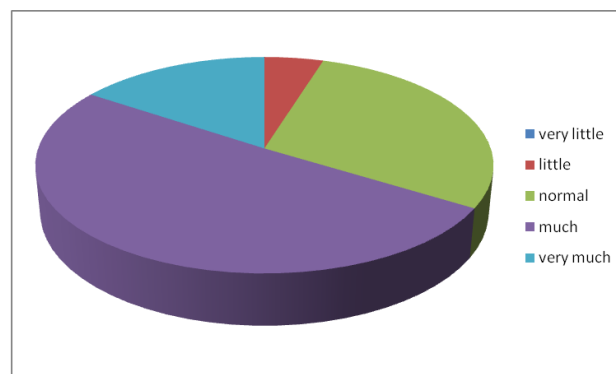


Fig.4 Students has learned

The last question was about evaluation system. Almost everyone (except one student) thought that this system was suitable. This quiz was taken before exam, so the results weren't affected by exam results.

6.2 Results

The Fig. 2 shows that students did very well in tasks during term. In fact more than half of them gained maximum points. Students mostly rated course easy or normal and tough that they learned normal or much. But the question is: How well students at exam succeeded? Firstly we must look at the exam grades and the relevant points for that grade:

- A – excellent results with minimal errors (100 – 92 points)
- B – above-average results with less errors (83 – 91 points)
- C – fairly well, average results (74 – 82 points)
- D – satisfactory results but with significant errors (65 – 73 points)
- E – sufficient results that satisfactory minimal criteria (64 – 56 points)
- FX – insufficient results, completing of the course expect more efforts and knowledge form student (less than 56 points)
- FN -student did not come to the exams test.

Points are sum of points acquired during term and exam. Next figure (Fig. 5) shows final grade for our students.

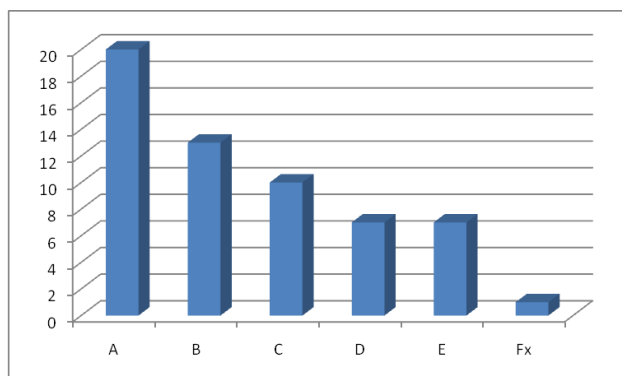


Fig.5 Students grades

As you can see there is significant change between graphs at exercises and at exam. From first graph we would expect more students with better grades. We have to ask our-self, what could cause such difference. The first reason could be exam self. On exam students can acquired up to 60 points. It is a lot education classification so they have to be divided into several questions. The questions have to reflect whole course knowledge so students have to repeat and learn more at the exam. If the student thought that they have learned much this can't be big problem for them. At the end this can be problem because they could underestimate the exam.

The second reason could be psychological. The good educating result from exercises couldn't motivate students enough. Student with high quality result probably thought that they have enough grade of result to pass exam and didn't needed to get better grade. Maybe they concentrate on the other courses more to pass them.

7. Conferences

Self learning is important part of education. It is also important to extend our knowledge by other people experiences. Conferences are the best place to do that. Participants from other institutions come to conferences to present their work and discuss about related topics. We are also trying to participate at Matlab conferences to extend our knowledge. The two main conference events in our region are Technical Computing and Academic Virtual Conference. Both of these are serving as another source of information for students and teachers as well.

7.1 Technical Computing Conference

Every year in autumn company Humusoft organize conference focus on technical computing. Past

events were hosted at the Congress Center of the Czech Technical University in Prague. Conferences were dedicated to presentations of MATLAB / Simulink, dSPACE and COMSOL Multiphysics users. Program of the conference also included the latest information on these products and seminar for COMSOL Multiphysics. Last year there were more than 100 papers presented.



Fig.6 Technical Computing Prague

We participate at this conference and present our results in education and science. We also motivate students to participate on the conference. Many of them have bachelor or diploma thesis in Matlab. We try to direct them to work on interesting topics that are worth to present on conference. One or two papers at the conference come from our student every year.

From this year Technical Computing Conference will be also hosted by Bratislava. We agree with our colleague from Czech Republic that we will alternate in conference hosting every two years. We are also hoping that conference will have good achievements like last years and for rich participation.

7.2 Academic Virtual Conference

On the 11th of May 2010 global event did take place all around the world. MathWorks Academic Virtual Conference joined professors, educators and Matlab users from the praxis. The aim of the conference was to bridge the gap between theory and practice. Participants learned how to incorporate latest The MathWorks technologies into classrooms and laboratories.

The keynote speaker Jim Tung from The MathWorks talked about key technologies and trends that are impacting engineering and science, and how these trends are creating opportunities and

challenges for educating and preparing the next generation of engineers. His fellows from The MathWorks talked details about other products that enhanced education. Then the others speakers told their stories how they teach with The MathWorks products in the classrooms and laboratories. After presentations few minutes for online discussion were available.

Between the presentations was the time to visit the exhibition hall. At the hall participants could visit booths to chat with staff, view products demonstrations and download literature. Two kinds of booths were available – The MathWorks booths and Participating partners booths.

We decided that we will actively participate on the conference. We made some posters to inform our colleagues and students from faculty about event. The conference room at our faculty was equipped with projector which projected presentations onto large screen and with internet connection that our participants could connect to the event from own computers. After presentations we discussed the topics and try to ask the questions online to the speakers. In the exhibition hall time we joined some booths to talk with The MathWorks experts about topics that we were interested in. The whole event was one big experience and we learned many new things about current trends in education and learning.

8 Conclusions

In this paper we wrote about Matlab course at the Faculty of Electrical Engineering and Information Technology Bratislava. Because we cover many topics in single course, it is important that students are able to pass tasks for every practice. They can use a lot of materials, mainly lectures. But there are several others materials that can they use like original Matlab documentation, web-pages. Students can collaborate through forum and social networks like Facebook. Great motivation is to evaluate their results weekly, too.

On practice there they have to solve some problems within the given time range. So students must come to the practice prepared very well, if they want to get a good point result. We can say, that we are “forcing” them to learn continuously. As the result of the anonymous questions at the end of course shows that they prefer this system. We know, that this system fits from students because there are saying (it is within anonymous questions):

“The best course so far! I have learned many handy

things in Matlab and Simulink. Lectures were explained clearly and practices adequately.”

“I liked challenge that I must doing everything on the practice (what I never done before), mainly at the end of the course it was very interesting.”

Of course within many positive reactions we found some reactions that can lead us to make even more suitable course for students. The most are about using more practical approach than theoretical:

“It would be suitable to show something from praxis not only virtual. For example motor.”

In the last group of reactions there students wanted to take the course sooner than in the second year and second term. Teachers from the other courses have this requirement too. For this reason the Matlab course is shifted to the first study year in second term. Hopefully we keep up the most students satisfied and educated.

Acknowledgement

We would like to thank Slovak Scientific Grant Agency VEGA for their support of this paper by grant No. 1/0544/09 and 1/0592/10.

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