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# Education of Future Advanced Matlab Users

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Additional information is available at the end of the chapter

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## 1. Introduction

Technology surrounds us in every step we take. Computers, mobile phones or cars would not exist without smart researchers and innovators. We need more and more engineers and scientists to sustain technological growth. The current state of technology and technological growth is facing two problems. The first problem is population declining in many countries. Germany is a country with least population growth in Europe, for example. The second problem is that many industrial and research centres demand high quality engineers (Blau, 2011). These two problems come hand in hand as you can imagine. Society can affect both of them in some way but providing high quality engineers is what we can affect at fastest. Learning is an important process in our lives. Educational institutions prepare students to fulfil requirements from the society. There are many modern methods and technologies for learning but most of them have one in common today – computers.

Computer aided learning has found a way in learning process from primary schools to universities (Abdullah et al., 2010, Bertrand, 1989). Computers are also significantly involved in teaching technology serving sciences like mathematics, physics and information technology. Technical computing plays an important role in these specializations. Many software applications are accessible for teaching as Matlab, Octave, Scilab and Mathematica, for example. Other specialized programs exist as well, but they are often used to solve specialized problems and tasks. Therefore we are not going to mention them. The worldwide most spread applications at educational institutions used by is Matlab, which is considered as standard in technical computing and science (The MathWorks, 2012a). Matlab is a very powerful tool for computing and simulation. Basic mathematical core provides functions for high performance computing. On top of that, Matlab provides add-ons (toolboxes) to enhance its usage via adding more functions in specialized fields of technology, economics, medicine or biology. Matlab is also applied in many publications in different fields. Matlab is not only exploited in computations but also in the process of teaching and learning. In the Matlab environment there are small GUI applications that can be created to improve learning (Andreatos & Zagoranos, 2009).

Extensive usage of Matlab demands high quality courses at educational institutions (Dogan, 2011). In fact multiple courses for different topics can be taught with the use of Matlab. To provide students with solid background for these topics, an introductory course for Matlab can be created. At our faculty we create such a course. The aim of this course is to gain basic skills that students can use in more advanced courses. Our course is divided into two parts. In the first part there are Matlab basics that every student must to know (Matlab basics, graphics and Simulink). At top of the basic specialized topics a more advanced courses are introduced to help during teaching topics that students will need later. Although we teach the Matlab course at our faculty we believe that Matlab can be used at secondary schools as supporting tool for the teachers. Matlab basics and graphics can be also taught to students at secondary school level (M. Varga & Z. Varga, 2010).

Students have different types learning capabilities. We cannot satisfy all of them, but we could motivate them to achieve the best possible performance. One of the proper motivator is their evaluation (Blaho et al. 2010a, 2010b). If students can see that the hard effort is rewarded than they want to learn more and more. The other motivator is collaboration. Many students are competitive by nature and they want to achieve better performance than others. On the other hand the collaboration can help them to solve problems that they are not able to solve for hours or days. Therefore collaborative learning is a very important for them because students learn to work in the team as well.

The Internet is popular among the students. Students search more and more for information on the Internet. Studies show that many students consider the Internet as a great source of information and using it during learning process. The Internet is full of e-learning projects, documents, presentations and multimedia content that students may find useful for their learning process (Foltin 2012b, 2012c). It is necessary that all our contents for courses are available online as well. Courses can be also supported with custom video tutorials where topics are explained and shown. Mathworks also provide online content like the documentation, webinars and events on their official web site. Conferences are also good events for students to exchange their knowledge among each other (MathWorks 2012a, 2012b, 2012c). Learning and teaching process is often high cost. Free software and open source applications are possible solution (Foltin et al. 2011).

In this chapter we will describe possibilities for an introductory Matlab course. We will show how to divide lectures and practices into several topics necessary and helpful for the students. Weekly task evaluations are proposed to motivate students to achieve better results. We will described how to find an interesting resources for the course or how to create own one. Collaboration among students is described within the Internet with the Facebook, articles or forums. Over all we focused on the educational use of Matlab, concepts for lecturers and the course improvements.

## 2. Matlab course

Matlab is a very powerful tool for technical computing and simulation. It is time saving tool for high performance computations. Matlab is optimized for this kind of tasks. It supports

us when we lack of real world system in the education. Matlab contains many add-ons that are very useful in many fields of science. Matlab usage is a very popular in many science projects, bachelor, master and dissertation theses in the university environment. The basic Matlab course was established at the Faculty of Electrical Engineering and Information Technology in Bratislava to teach students to use Matlab and its add-ons. Matlab is a basic tool for every student at our faculty. We try to move this course into the first year of study for this reason. The knowledge, which students take from this course is a very useful in the other technical courses.

## 2.1. Lectures

As we mentioned before at the Faculty of Electrical Engineering and Information Technology Bratislava there is Matlab used in many mathematical and technical courses. Students use Matlab for their computations and solutions in their bachelor, diploma or dissertation theses. Matlab course is introductory course to Matlab, Simulink and Matlab toolboxes. The faculty has two terms per year. Each term lasts twelve weeks. Course can be taken in second term of the first year of undergraduate study. It consists of one lecture (100 minutes) and practice (100 minutes) per week. The lectures are not compulsory, but practices are. Count of the attendance at lectures is more than a half of all students. The lectures are combination of explanation of the current topic, solving of basic tasks and discussion. All of tasks are solved directly on the computer using Matlab. The students are allowed to see how to solve the concrete problem and can write the notes into their hand-out. The full preprint of lecture is available a week ahead on the web pages of the course. The students can print this hand-out before the lecture. The hand-out with notes are useful source of the information for the practices. For this reason there are usually students who attend the lectures more successful than students who do not have the notes from the lectures. The aim of the Matlab course is to introduce students to the Matlab, to learn 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 the lecture time we just cover a simple introduction to these topics. That is not a big problem because they will have

detailed courses for most of the mentioned topics in the future. The main idea is to show basic principles and solutions to students that Matlab could provide. They can extend knowledge gained from the Matlab course on the other courses.

## 2.2. Practices

The practices are related to the lectures. Students are solving some problems similar to the topic on the actual lecture. Problem is at the first solved verbally and using the board. Students then try to find out solutions in the Matlab environment. This is a time for notes from the lecture. Practices are set up in the way that students have not much time to learn the topic on the exercise and they have to always come prepared. Every student has his computer and work alone. They can use the computers with Microsoft Windows, GNU/Linux or Mac OS X operating systems. Students can also use their own notebooks. These facts improve the environment in the class. There are two lessons that take hour and forty minutes together. Teacher checks and rate every students work about ten minutes before end of the practice. The tasks are prepared for students that they should finish the given tasks before hour and half without problem. Many of students can solve given problems successfully in time.

## 2.3. Matlab at secondary schools

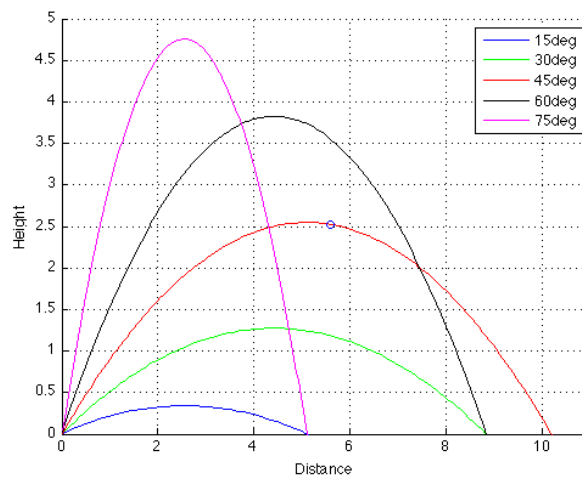
Although we teach Matlab course at university the question is if we could find usage of Matlab at lower levels of education. The answer to this question is of course yes. We think that Matlab is great supportive program for secondary schools teachers and it should be used in mathematics and physics courses. For example let us look at this two equations:

$$x = x_0 + v_0 t \cos(\alpha) \quad (1)$$

$$y = y_0 + v_0 t \sin(\alpha) - 0.5 g t^2 \quad (2)$$

Equations represents trajectory of an object thrown in 2D plane from start point  $(x_0, y_0)$  with speed  $(v_0)$  at some angle  $(\alpha)$ . With given acceleration due to gravity  $(g)$  we can compute distance  $(x)$  and height  $(y)$  of objects trajectory at certain time  $(t)$ . In the next figure you can see trajectories for different angles with same start point, speed and gravity.

In the most of the secondary schools teachers and students compute results on the table or the paper. Matlab can be used to visualize different trajectories in just few lines of code for better understanding and imagination of the problem. With additional commands we could animate whole movement. This is one of the examples how to use Matlab in secondary schools physics classes. Another question is if Matlab should be considered only as a supporting program for the teachers or if students should also learned know how to create own scripts and programs. We think that we should consider both. Benefits of the first part of the question were answered with our example before. Writing Matlab scripts and programs should not be a problem for the students also because of its simplicity. We think that for students it would be also interesting. They would also learn some basic concepts of algorithm writing.



**Figure 1.** Trajectories of thrown object

### 3. Matlab course topics

In previous chapter we generally talked about the Matlab practices and lectures at the universities. We briefly showed how you could use the Matlab benefits in secondary schools also. This chapter will discuss topics suitable for basic Matlab course. We divided topics into three categories. Essential topics are parts of Matlab that every student should know because they provide strong platform for advanced topics and other Matlab toolboxes. Advanced topics should cover additional parts of the Matlab necessary for later student courses. We will describe topics that we cover in our course but other interesting parts of the Matlab suitable for other study programs are described in other interesting topics.

#### 3.1. Essential topics

With Matlab core components come several add-ons as well. It is necessary to know all about basic Matlab concepts before we start to use specialized toolboxes suitable for our needs. In our opinion the essential topic for advanced Matlab users should be Matlab basics, graphics, Graphical User Interface and Simulink. Next we will talk in the detail about each of them and on what we should focus at most.

##### 3.1.1. Matlab basics

Understanding of the Matlab basic principles is key to be successful advanced Matlab user. Students should know how to use Matlab windows (Command Window, Workspace, History) and the benefits of each of them. Effective usage of Matlab help system is also necessary to solve Matlab warnings and errors. It is our choice if we use fast help command or Matlab Product help where user can find detailed information. Basic computations can be made in the Command Window through statements or in scripts (M-files) for example area of the circle. For additional support we can use the built-in Matlab functions for complex numbers or trigonometry functions. What makes Matlab powerful tool are vectors and



matrices. There are several ways to create and manipulate them. Working with indexes of matrix is a very important and challenging parts in the Matlab for students, even harder with indexes range. Programing in the Matlab with functions, loops or conditions is one of the highlights of Matlab basics. In our course we are creating simple sorting algorithms. Students must then use almost every part of Matlab basics that we mentioned in this section. We are also teaching advanced data types – structures and cells. Data types are often used as types for output or input arguments to several Matlab functions.

### 3.1.2. Graphics and graphical user interface

Functions and scripts provide sets of commands necessary for computing output data. Reading plain data is hard and we need some mechanism to represent them. Matlab contains several plotting commands for 2D and 3D figures. In 3D plotting we need to create grid for 3D space through meshgrid command. Some students have a hard time to understand this concept. Changing plot properties is another important knowledge. We must create handler to plot and using get and set commands we can change line colour or type. We can also use standard Matlab handles like current axis (gca), current figure (gcf) or current object (gco). Matlab enable creating graphical user interface. With objects like buttons, labels, inputs or check box we can create interactive experience for users with no prior Matlab knowledge. Students like creating user interfaces, but concept of the handles structure and callbacks can be sometimes difficult for them. We are trying explained this concept clearly and showed them how to call callback from another to reduce necessary commands.

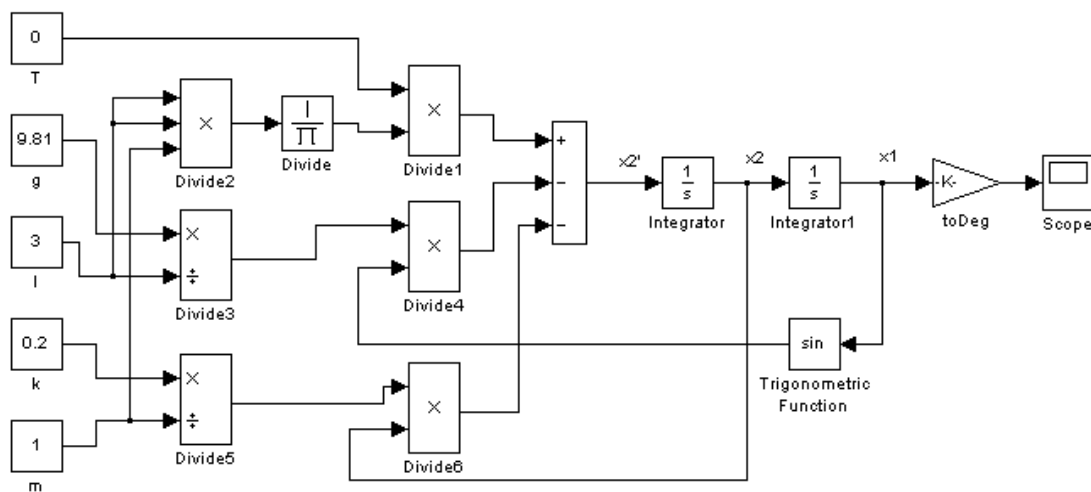
### 3.1.3. Simulink basics

We can start model dynamical systems after Matlab basics lectures and practices. Dynamics of any system can be expressed with differential equations and computed by ode solvers. With Matlab ode solvers users must write functions with differential equations. More natural way provides the Matlab extension Simulink. In Simulink we building simulation schema from graphical blocks, signals and then customizing parameters in the blocks. Simulation can be continuous or discrete. After Simulink basics we create simple DC motor model schema from differential equations of the mechanical and electrical parts. Critical part for the students is relation between variable and variables differential, how this is modelled through integrator block and how to set initial conditions. On the practice students are modelling following equations:

$$\dot{x}_1 = x_2 \quad (3)$$

$$\dot{x}_2 = -g/l \sin(x_1) - k/m x_2 + 1/(l^2 m) T \quad (4)$$

Equations represent simple pendulum differential equations where variables can be mass (m), length of the pendulum (l), acceleration due to gravity (g) and k is representative of the amount of damping present. Simulation schema for these equations is in the next figure.



**Figure 2.** Simulink schema of simple pendulum

Students can change system parameters to simulate how motion of the pendulum change. Standard simulation is with no input ( $T$ ) and 90 degrees as initial pendulum position.

### 3.2. Advanced topics

After the essential topics lectures and practices it is time to choose advanced topics. Advanced topics depend on a study program of the students. Because our students studying cybernetics and robotics we focused after basic topics to topics related to their curriculum. In this session we are describing some of them next.

#### 3.2.1. Identification

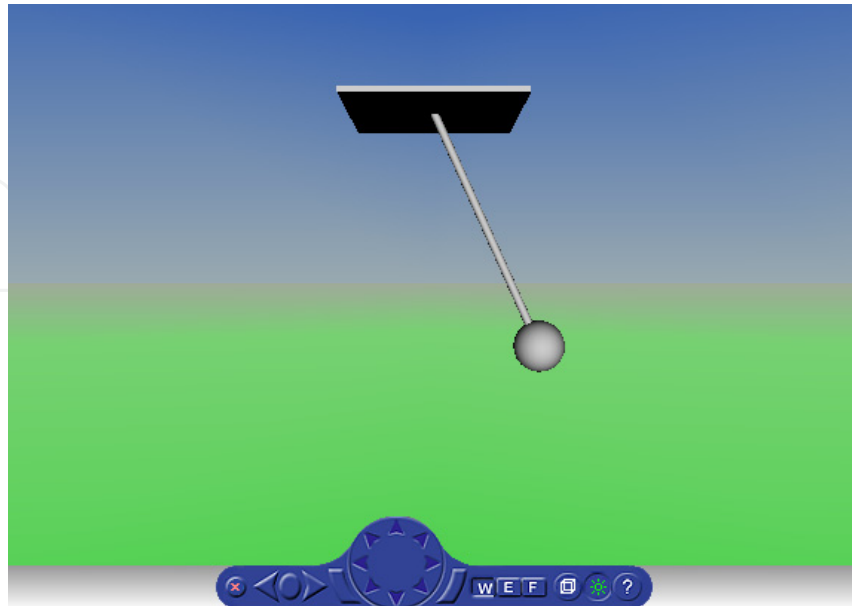
In real world we often do not know structure of the systems (gain, constants, etc.). Systems can be identified through regression methods with input and output data. Regressions methods are part of the Matlab in System Identification Toolbox. Widely used model estimations are ARX and ARMAX models. Another possibility to achieve approximation of the system is with neural networks. In our course there we use both of them to introduce basic principles of both methods for the system identification.

#### 3.2.2. Virtual reality

Signal values from the Simulink models can be plotted into charts. These signals can be also used for animation of models and Simulink 3D Animation provides this capability. Virtual Reality Mark-up Language represents 3D models using basic shapes and properties like geometry, appearance or translation. Virtual reality worlds can be built using several programs but the Simulink 3D Animation includes V-Realm Builder. Build 3D world is saved as \*.wrl file and with VR Sink Simulink block we can interact with our simulation. Building 3D animations is one of the interesting topics of our course for students and they are really enjoying it. With the differential equations from previous practices we are



animating simple pendulum that oscillates from right angle to equilibrium. Visualization of this system is in the next figure.



**Figure 3.** Trajectories of thrown object

### 3.2.3. Fuzzy logic

Describing behaviour of real world systems with differential equations is often very challenging. Humans can control cars without knowing its precise description. Fuzzy logic can model systems in the terms of If-Then rules natural to our thinking. Inputs and outputs to the fuzzy system are modelled through fuzzy membership functions. In our course there we introduce students into the basic concepts of fuzzy logic and then they modelling some decision problem. One of the problems is student own grading system where there are two tests, one exam and they must write rules based on the point gain for each one of them. Some interesting grade scales came often as result.

### 3.2.4. Stateflow

Most of the systems can be described as continuous (variables depends on time) or discrete (variables are time-sampled). Some systems react to events and we do not know exactly when system change happens. These systems are called event-driven. Event-driven systems are important to know because they can be found in the industrial applications. They can be modelled by several methods like Petri nets or Statecharts. Matlab prefers Statecharts through Stateflow, which is design environment for developing them. The states and transitions between states are represented graphically. Graphical representation is very useful within simulation where user can see which states are active and when system reacts to event through the transitions. For the Stateflow practise we are asking students to observe real word and look for examples of event-driven systems. They came out with interesting observations like the elevators, intelligent traffic light sensors or door openers in public

transportations which all react to the human touch. We are choosing and modelling one system into the Stateflow together.

### 3.2.5. *Real time*

Simulation in the Simulink does not respect real time. If the Simulink schema is simple to the simulation it will be faster than in real time and if schema is complex simulation will be slower than in real time. If we interact with real systems though the Simulink we must ensure precise timing. Interaction with the real time systems is necessary for the measuring physical values (inputs) and reaction to them through outputs. Port of computers can be used to do that with sound card, USB, parallel or serial port even with specialized measuring cards. Real Time Toolbox that is not part of the Matlab can provide real time in Simulink (Humusoft s.r.o., 2012).

Real Time toolbox is only available for the 32 bit Microsoft Windows operating systems and can provide precise timing (standard usage is around 0.1s). Another real time communication can be made by OPC toolbox. With OPC toolbox we can connect, read and write data to OPC server. With large amount of OPC server distributors we can communicate with almost every Programmable logic controller widely used in praxis. For the educational purposes OPC server simulators can be used for example from the company named Matricon (MatriconOPC 2012). This server generates signal that we can read and draw in the Matlab/Simulink. We can also write our data to provided space of the server and then to the process or controller.

### 3.3. Other interesting topics

In the advanced topics there we described topics that are useful for students at our faculty. There are many toolboxes suitable not only for engineering study programs but also for other like economics (Financial Toolbox, Fixed-Income Toolbox, Financial Derivatives Toolbox) or natural sciences (Bioinformatics Toolbox, SimBiology). Toolboxes that we did not mention in this session can be introduced in other courses, bachelor or master theses. We think that future is in code generation for various devices (FPGA, Embedded devices), or hardware in the loop simulation but variety of the Matlab toolboxes specialised for other topics are popular as well.

## 4. Tasks evaluation

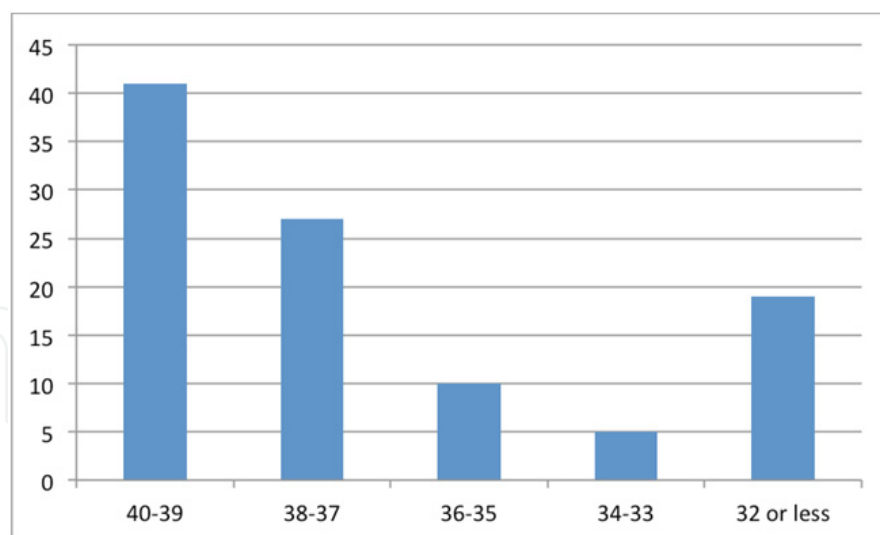
Results of the students are evaluated through point assigning for each course independently at the Faculty of Electrical Engineering and Information Technology Bratislava (Blaho et al. 2010a, 2010b). Students can achieve 100 points at most. Most times points are divided into two parts. The first amount of the points can student achieved for their activity at practices or tests through term. The second part they can achieve on the exam test. In the most cases it is 30/70 (practice/exam) or 40/60. Weight is on the exam as you can see. Maximum amount of the points allowed during term is 50 for the undergraduate courses.

### 4.1. Week task

There are two main evaluation (or result classification) systems. The first system classifies students via two or three checkpoints through term. All comes to these tests at the end. Point results depends on how successful are students to answer the test tasks. It is a little bit problematic when students doing great at the practices, but they vacillate on the tests at the end of course. They also do not have to learn until a test is in sight. This problem had been observed long time ago at the mathematics teaching. Students came from high schools and they were not used to learn so much or they had different knowledge background of the mathematics. Many of them fail some of the basics mathematics courses.

Mathematicians try another pointing system that “forces” students to learn more often than just before the tests. Students were evaluated at the every exercise. On the next exercise they had small test on previous topic. The results of the student grow significantly. We also used this schema. We had two reasons for that. One reason was that we had many topics covered in our course. It would be not useful to test student on topics they forget long time ago. Another was that we want to “force” students to do something more. We choose to give more points during the term, so we give 40 points maximum for the practices. There were 10 practices for 4 points each. The first and the last were not evaluated. You can see results from year 2011 course classification distribution in the next figure.

With weekly tasks evaluation students gained good amount of point that they carry to the exam. This type of evaluation does not fit everyone and in the next part of this session we will be talking about its advantages and disadvantages.



**Figure 4.** Point distribution for practices

### 4.2. Advantages and disadvantages

Every student has different capability to learn. We cannot choose unified methodology to learn them all that we know. But with proper motivation they will be willing to learn by themselves more within their free time outside the university campus. Our week task

evaluation is kind of motivation factor. Reachable classifications are motivators for being excellently prepared for practices. Now it is time to talk about advantages and disadvantages of our method. We think of these advantages:

- Students must come prepared for practice
- 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 you can see. The question is if this system works for students and if it is acceptable for them.

## 5. Study materials

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 a really powerful tool for computing, but for many years also for communication and sharing information. In fact, the basic idea for the Internet was collaboration across the continents with other researchers. We significantly use this tool today not only for sharing information but also in the teaching 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).

### 5.1. Open source technologies

For some student education can be expensive even if it is for free (like in our country). Reduction of the costs is our priority too and we try to be supportive for them. We are trying to work with open source technologies that are comparable to commercial technologies. We support students to use free UNIX-based operating systems (Linux distributions). For creation of lectures and practices we use Open source productivity suites like OpenOffice.org or LibreOffice. They are used to exchange documents and spread sheets. All presentations are created using these office suites.

### 5.2. Course online study materials

Internet is great source for information exchange as we mentioned before. Modern student's first choice for material search is Internet at the moment as well. For this fact we build web page for the 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. Our web pages are prepared using iWeb software. This is WYSIWYG editor for doing web pages. The advantage of this software is they provide very good graphical user interface. It is not a problem to add the new lectures and important information for students by several clicks. For this reason it is possible to update the web page as often as possible. Web pages are divided into sections. The most wanted sections are about the lectures and practices. Students can find lectures and exercises materials there in electronic form. Also detailed information about both is available from there. A few topics have own video tutorials and students are able to view them at home and they can be better prepared for the practices. Video tutorials have main advantage. Students can directly see what the teacher is doing and therefore that is easier to then to understand topic. Some of the video tutorials are mentioned in references. We would like to publish these free video tutorials in Apple Store iTunes U in the future.

Computers connected to the Internet access are present at the practice room. Students can find their problems solutions on the web pages. On our webpage at which we publish student's articles we decided to write small papers about Matlab in Slovak language. Papers slowly cover the Matlab topics so the students have many tutorials. Beyond the articles discussion to the paper is available. We also publish some experiences on our publishing portal named Posterus (Systémy priemyselnej informatiky s.r.o. [SPR] 2012a).

### **5.3. Mathworks online study materials**

The lectures are not only source of the materials. Students use many different materials at the practices. The main material for Matlab study could be the Matlab reference manual that 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. Mathworks support education of all parts of Matlab through various online content (The Mathworks 2012a, 2012b, 2012c). Online events called webinars are recorded regularly and they are available for later use. Webinars are categorized by date of the recording, application, product and industry. This helps users to fast find necessary contents. Many languages are supported as well and that helps overcome language barrier for the novice users. We also contributed by creating webinar for Stateflow introduction.

### **5.4. Seminars and conferences**

Online content is very useful but human interaction is important as well. This can be done on events like seminars and conferences. Seminars take place regularly by local Matlab providers just like webinars. Participants from other institutions come to seminars to learn and discuss about related topics. Another types of interactions are conferences where students or scientists can present their work. We are trying to participate at Matlab conferences to extend our knowledge and trying to incorporate student in them as well.

#### 5.4.1. Conferences for students

Conferences for the students are great place to present their results. At our faculty students can present their work at two conferences. SVOC conference is for the students from bachelor and master level of study. On this conferences student can also gain some presentation skill that will help them at the final exams later. ELITECH conference is for the students from postgraduate level of study. This conference is more scientific oriented and can be as start conference for other local or international conferences.

#### 5.4.2. Conferences for scientist and educators

The Humusoft Company organizes conference focus on the technical computing every autumn. Past events were hosted at the Congress Center of the Czech Technical University in Prague. Conferences were dedicated to presentations of the MATLAB / Simulink, dSPACE and COMSOL Multiphysics users. Program of the conference also included the latest information on these products and seminar for COMSOL Multiphysics. We participate at this conference and present out results in the education and science. We also motivate students to participate on the conference. Many of them have bachelor or master thesis in Matlab. We try to direct them to work on interesting topics that are worth to present on the conference. One or two papers at the conference come from our student every year.

Every year Mathworks is hosting global event. MathWorks Academic Virtual Conference is joining professors, educators and Matlab users from the praxis. The aim of the conference is to bridge the gap between theory and practice. Participants are learning how to incorporate latest MathWorks technologies into the classrooms and laboratories. Conference is divided into the three regions (Asia-Pacific, Europe, America) for people from the different time zones. Between the presentations it is 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 are available – MathWorks booths and Participating partners booths. We actively are participating on this conference. 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 MathWorks experts about topics that we are interested in.

## 6. Interaction of students

Collaborative learning is a very interesting area. Students are helping each other to better understand some topics. Main advantage of this method is that student did not stuck and some part of topic that he did not 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.

### 6.1. Matlab forum

To support collaborative learning we founded Matlab forum. Students can ask any Matlab related questions on the forum. It is not forum just for our course. The questions can be



related to various problems at which students came through on their study in every course and are about Matlab. We answer most of the questions, but there are some others responders that can easily support us when we have not enough time. They include local Matlab software distributor employers. Now 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 (SPR 2012b).

## 6.2. Facebook

Speaking of the Internet and collaborative learning we must also mentioned social networking. Social networks are very popular today. Majority of people are present at least at one social network. Most favourite social network is the Facebook today. Like the Internet, Facebook also started on the academic field. The website's membership was initially limited by the founders to the Harvard university students at Cambridge, Massachusetts, but was expanded to other colleges in the greater Boston area. Facebook enables to create groups. Groups can be created by topics like interests or activities. We established new Facebook group for the students of the Matlab course (Foltin 2012a). This group has several active members who are mainly students of our course. We use this group for quick and short information about the course. Every member can comment tasks from the 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.

## 7. Results and opinions of the students

To improve our course even more we study the students study results and their feedback every term. First of all we compare distributions from practices and grade results. Then we are giving some questions to the students at the end of the term. Some information and feedback we have already gained through the Facebook and Matlab forum during the term.

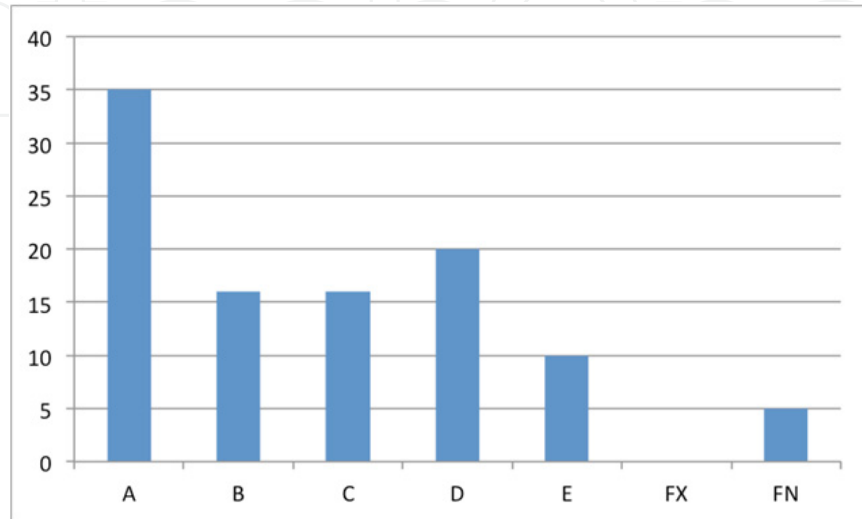
### 7.1. Results

The figure 4 shows that students did very well in tasks during term. Almost half of them gained maximum points. But the question is: How well did 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 from 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 shows final grade for our students.



**Figure 5.** Grade distribution

As you can see there is a change between graphs at exercises and at exam. From the 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 itself. 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. The second reason could be psychological. The good educating result from the exercises could not motivate students enough. Student with high quality result probably thought that they have enough grade of result to pass exam and did not needed to get better grade. Maybe they concentrate elsewhere to pass on the other courses more.

## 7.2. Opinions of the students

Most valuable information in control comes from the feedback. Such data comes from student responses to the anonymous survey. Our university information system supports such surveys for each course. Most interesting answers are for listed questions:

- How would you rate the lectures?
- How would you rate the practices?
- Were the topics explained clearly?
- How do you rate the course difficulty?
- Do you like the system of work evaluation on every exercise?

The answers depend on the individual students, but most of them agreed at some points. The lectures and practices were rated positive. Explanation was clear, but they want more practical examples. Most of the students answered that course difficulty was normal or course was easy. In the comparison with other courses was that the Matlab course difficult same or easier. The last question was about the evaluation system. Almost everyone thought that this system was suitable. This quiz was taken before exam and therefore the results were not affected by exam results.

## 8. Conclusion

In this chapter we described the educational side of Matlab usage. Different specializations can benefit from many Matlab products in high quality education. We described how we teach Matlab at our faculty and how are dividing lectures into several topics. We also talked about how to incorporate Matlab into secondary schools education. Topic for future engineers was divided into three categories as well. Basic topics should every engineer to be able to pass, advanced topics depend on study program specialization and other topics are suitable for the research or student thesis. Evaluation of student's performance is a difficult process. In the most cases students are evaluated few times a term. With our proposed evaluation student are forced to study before every practice. Internet is first choice for seeking information for students. It is necessary that we adapt to this fact. We are preparing much online content for students like articles or videos. Collaboration between students is beneficial and we should use social networking. Events like conferences and seminars are helping with education as well. Student's opinion showed that proposed evaluation strategy for the practices suits almost every one of them. Our novel approach to the Matlab teaching process is recommended to copy for another universities as well. We hope that this chapter will helped create high quality courses.

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