

# THE IMPORTANCE OF STUDENTS' ALGORITHMIC THINKING SKILL IMPROVEMENT

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***Abstract:** The paper deals with the author's experience in the field of students' algorithmic thinking skill building and improving. He describes his interpretations of data collected at the Faculty of Military Technology, University of Defence, Brno, Czech Republic. The author assumes that the validity of his findings (outcomes) is wider than his faculty environment and used approaches can inspire the academic staff who is interested in the described problem area.*

**Keywords:** algorithmic thinking, education, IT, problem solving, programming language.

## INTRODUCTION

The Czech high school graduates who enter universities, have different levels of their algorithmic thinking skill. Some of them have never used any programming language yet and their knowledge of appropriate terminology is also at a very low level. On the other hand, especially contemporary technical education has a close connection with IT and the achieved level of knowledge and skills in this field can be significant information for the work of teachers. The paper deals with the author's experience in this field gained from the environment of the Czech military university. He describes his interpretations of data collected there. The author assumes that the validity of his findings is wider than his faculty environment and the task of algorithmic thinking skill building and improving can also be supported by modern tools of distance learning.

## 1. FACULTY OF MILITARY TECHNOLOGY ENVIRONMENT

From the point of view of new students of the Faculty of Military Technology, the faculty environment can be described as follows:

Since the academic year 2014-2015, the Faculty of Military Technology has run, according to the new requirements of the Czech Ministry of Defence, its new five-year Master's degree program „Military Technology“. This study program has only one study field which is also named „Military Technology“. The subjects and study duties in the first 5 semesters are the same for all military students but from the 6th semester this study field is internally divided into 15 modules that correspond to the names of the required military specialties.

Since the academic year 2015-2016, the new three-year Bachelor's degree program „Technologies for Defence and Security“ has been offered for civilian students. This study program has three study fields:

- Communication and Information Technologies;
- Technologies for Protection of Assets and People;
- Weapons and Ammunition.

In the winter semester of the first year of studies the subject „Information Technology“ (IT) is included in all four study fields above. The current specification of this subject in the first part of its content follows (Hrubý 2012) and (Hrubý 2013). The subject IT is planned for 48 teaching hours for military students and 60 hours for civilian students.

## **2. CRUCIAL INFORMATION ABOUT A TARGET GROUP**

According to the author's experience, teaching of the subject IT should respect some crucial information about every member of a target group such as:

- Previous education type and duration (where the leaving exam was passed; next possible education after high school graduation);
- IT education content;
- Computer ownership;
- The current average duration and methods of use of a computer;
- The current ambitions in IT.

The thinking style of students is often significantly affected by the type of their high school where they took their school leaving examination. In the Czech education environment it is suitable to distinguish:

- 8-year grammar school;
- 6-year grammar school;
- 4-year grammar school;
- vocational high school;

- apprenticeship with a school leaving exam.

A minority of new University of Defence students had also completed higher vocational education or studies at another university. Some students had also tried to study at another university in the past but they stopped their studies before successful completion.

IT education content during the previous education, view of its usefulness, view of the outcomes and especially current knowledge and skills gained in the IT field can help the teacher to set the optimal methods and steps.

The ownership of a computer seems to be a current standard and the teacher should enable the students to use their own computers if possible. The knowledge of methods of using a computer by students and how many hours daily a computer is used can be useful for instance for the preparation for lectures and selection of suitable examples.

The current ambitions in IT can differ depending on self-confidence of students. If possible, the teacher should enable the appropriate individually tailored development in compliance with students' ambitions.

### **3. ROLE OF THE SUBJECT IT**

The goal of this chapter is to introduce goals of the subject IT, a study plan of the subject IT, its teaching methods and rules for granting the credit. The findings from the first semester teaching at military students are included.

#### **3.1 Goals of the subject IT**

First of all it is necessary to keep in mind that new military university students are coming from various types of secondary schools. Their IT knowledge and digital competences can radically differ. The course especially builds on secondary school knowledge of mathematics and physics, improves skills for PC usage and forms algorithmic thinking necessary for technically educated military professionals and civilian experts. Gained knowledge is useful for the study of next subjects in the curriculum.

Teaching both groups of students (military and civilian) is planned separately. Due to the obvious characteristics of new students and their educational needs, the goals of the subject were specified in two main aims for military students and three main aims for civilian students. These aims are as follows:

- Algorithms and programming (32 teaching hours);
- Computer networks (16 teaching hours for military students, 22 teaching hours for civilian students);
- Geographical data and GIS (6 teaching hours for civilian students).

Students should gain knowledge of methods of problem analysis, basics of programming techniques, principles and practical usage of event programming, the meaning of IT technical terms and principles of operation of various types of computer networks. They should be able to divide the problem into sub-processes, to create applications in particular development environment, to solve simple applications as a support for engineering activities, to assess the basic network components configuration for workstations, to design simple local computer network, to design methods of obtaining the status of network components in workstations. Students should be acquainted with the basics of analytical and programming work on a local computer and within a computer network. It was planned that laboratory topics from programming should be implemented using selected higher programming language (Python, JavaScript, C# or Visual Basic).

Finally, JavaScript programming language was selected as the most suitable tool for the practicing of programming skills. This programming language was evaluated at the department level as a modern and popular tool which is available free of charge as a component of contemporary web browsers. Teachers and students can access many good information sources on the Internet, e.g. (Haverbeke, 2015), (JavaScript tutorial, 2015), (Moncur, 2015), etc.

### **3.2 Content of the subject IT**

The first part of the subject is focused on algorithms and programming. Firstly, three lectures (3 x 2 teaching hours) are provided:

- Introduction into algorithms;
- Data types and data structures;
- Statements of a high level programming language, structure of a program.

Then, 26 teaching hours are given in the form of laboratory practicing of the topics such as:

- User interface of the program (application);
- Programming of the input and output;
- Usage of an array;
- String processing;
- Subroutines and user defined functions.

The second part of the subject focused on computer networks starts with a few lectures (8 teaching hours for military students, 14 teaching hours for civilian students):

- Introduction to computer networks, history, types and forms of realization;
- Network architecture reference model ISO/OSI, model TCP/IP;

- Local computer networks including wireless computer networks, Ethernet
- Fundamental suite of TCP/IP protocols;
- Planning the address space, CIDR, VLSM, routing.

Then, 8 teaching hours are given in the form of laboratory practicing of the topics such as:

- Addressing in a simple network (configuring user devices and basic network devices);
- Realization of simple network and their diagnostics (configuration of simple networks in practice, their diagnostics and troubleshooting).

The third part of the subject (only for civilian students) which is focused on geographical data and geographical information systems (GIS), starts with two lectures (2 x 2 teaching hours). Then, 2 teaching hours are given for practical work with GIS systems in a computer laboratory.

### 3.3 Teaching and Assessment of the Subject IT

The lectures are provided in a high capacity lecture hall for all faculty students at the same time but separately for military and civilian students. Lectures focused on algorithms and programming and lectures focused on computer networks are realized by two vocational specialists. Laboratory classes are provided for the groups of 25 students. In the academic year 2014-2015 five members of CIS Department academic staff took part in laboratory exercises. The teaching process was coordinated by the guarantor of the subject. For clarification, the three examples of tasks from programming are as follows:

#### *Example No 1:*

One-dimensional array (vector) named Charles has 13 elements. Give each element random whole number from the interval  $\langle 10; 99 \rangle$ . Find out how many numbers which are stored in the array Charles meet the interval of which limits are set by the user, e.g.  $\langle 55; 70 \rangle$ . Display all used data in the form which you find as the most suitable.

#### *Example No 2:*

Two-dimensional array (matrix) contains the results of written work from the subject Mathematics. The work was done by a group of 32 students. According to the position of a teacher's desk and each student's place in the classroom, the results of students are characterized as:

Teacher

1 2 2 3 3 1 2 1

1 3 2 1 2 2 3 3

3 4 2 2 4 1 2 2

2 3 2 3 1 4 4 3

Evaluate the occurrence of individual classification levels. Display all used data in the form which you find as the most suitable.

*Example No 3:*

Declare and check a user's defined function which has to make a calculation of the monthly cost of water for swimming pool cuboids with dimensions  $l$  (length) /  $w$  (width) /  $d$  (depth), which will be filled to  $p$  %. Water in the pool is completely changed  $n$ -times per month. The price of water is  $x$  CZK per  $m^3$ . Realize displaying the used parameters and the calculated cost on a web page. Suggest this listing in the form which you find as the most suitable.

From the three examples above it is evident that programming tasks are especially focused on the array data structure and statements of branching, switch and cycles. When solving practical tasks, the students should be familiarized with three basic control structures (sequence, branching and cycle) and their use in writing algorithms by means of a high level programming language (in its integrated development environment). The algorithmic thinking skill of the students is developed step by step.

The military students' knowledge and skills assessment is realized independently in two phases while the civilian students' knowledge and skills are assessed independently in three phases. Firstly, in the first part of the subject the students have to accomplish the tasks in algorithms and programming (written task and portfolio of solved examples). Secondly, later in the second part of the subject they have to accomplish the tasks from computer networks. Civilian students are also tested from the third part of the subject IT. The tasks are set by the teaching academic staff and each group of students has to fulfil the goals during their laboratory exercises. Finally, the students, who fulfil the stated goals in both two parts (civilian students in three parts) of the subject, receive the course credit.

#### **4. GAINED EXPERIENCE**

The first experience from the teaching process is the follows:

- It is a necessity to improve the algorithmic thinking of students.
- Inclusion of the subject "Information Technology" in the education of all Faculty of Military Technology students is very important for their future studies.
- The 1st semester is the optimal time for teaching the subject.
- The content of the subject, focused on algorithms and programming and computer networks, seems to be well done but it will be suitable to be

prepared to slightly modify the subject content appropriate to the experience gained.

- The current number of 25 students in the laboratory classes would be reduced to the number of 10 to 15 students in the interest of better communication and individual approach which is sometimes needed.
- If possible, it is necessary to encourage students to use their own notebooks because these students can make better progress thanks to the usage of devices they are familiar with.
- It is suitable to have all students install and use the same web browser. It makes better conditions for discussions among students and their teacher about various solutions of programming tasks.
- The topics of programming tasks should be selected carefully according to the contemporary knowledge of students in the laboratory groups and their interests.
- The teachers should creatively use connections to the problem areas of other subjects, e.g. work with vectors and matrices in mathematics.
- The author assumes that evaluation of the usage of different high level programming languages according to the teachers' offer and students' selection could bring interesting results for the subject guarantor.

## CONCLUSION

The subject "Information Technology" is a mandatory subject for all new military students at the Faculty of Military Technology, University of Defence, Brno, Czech Republic in the first semester of their Master's degree program since 2014. The same subject has been a mandatory subject for all new civilian students of Bachelor's degree program since 2015. It is a subject of so-called core knowledge. In previous study programs realized at the Faculty of Military Technology was no subject of such content which was mandatory for all students of the faculty.

The students are warned that the subject requires significantly different demands due to the previous knowledge and skills of students in the ICT field, especially focused on algorithms and programming. Both students and teachers have to keep in mind this fact.

Acquiring the algorithmic thinking skill is sometimes a long distance run but this type of thinking is a necessary prerequisite for successful studies at the military technical faculty and an important element of a contemporary professional profile.

The author assumes that students' assessment should always consist of a written part and a practical part. From the algorithms and programming point of view the written part should be focused on understanding of key concepts and connections among

key terms used in this vocational field, including understanding of simple parts of the code. On the other hand, in practical part of assessment the students should demonstrate their current programming skill. They should be capable of creating a required code and explaining their thinking process which led to this code.

Department of Communication and Information Systems which is guarantor of the both versions of the subject IT (48 teaching hours for military students, 60 teaching hours for civilian students), also supports algorithmic thinking development by organizing two conferences as follows:

- Distance Learning, Simulation and Communication (DLSC, 2015);
- Mathematics, Information Technologies and Applied Sciences (MITAV, 2015).

## REFERENCES

DLSC, <http://dlsc.unob.cz>, (accessed 31 July 2015)

Haverbeke, M., *Eloquent JavaScript: A Modern Introduction to Programming*. [online] at <http://eloquentjavascript.net/>, (accessed 31 July 2015)

Hrubý, M., 2012: *Počítačová podpora práce s daty*. In: XXX International Colloquium on the Management of Educational Process. Proceedings, Science. University of Defence, Brno, p.59-63, ISBN: 978-80-7231-866-7

Hrubý, M., 2013: *Předmět „Informační technologie“ při přípravě „Akreditace 2014“*. In: XXXI International Colloquium on the Management of Educational Process. University of Defence, Brno, p.1-9, ISBN: 978-80-7231-923-7

JavaScript Tutorial. W3Schools Home, <http://www.w3schools.com/js/default.asp>, (accessed 31 July 2015)

MITAV, <http://mitav.unob.cz>, (accessed 31 July 2015)

Moncur, M., 2015: *Sams Teach Yourself JavaScript in 24 Hours*. Pearson Education, Informit. [online] at [http://www.informit.com/library/library.aspx?b=STY\\_JavaScript\\_24\\_hours](http://www.informit.com/library/library.aspx?b=STY_JavaScript_24_hours), (accessed 31 July 2015)

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