Human Capital in Information and Communication Technology[1]

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Summary

Information technology became the most influence factor on business changes in last thirty years. All over the world are investigated its impacts on economy. One of the most important factors of information technology improvement is human factor – Do we have enough qualified staff for technology improvement and operation? How does it look with perspectives in tertiary education in information technology education in the Czech Republic? Some aspects of survey realized at University of Economics, Prague since 2006 to 2007 are presented in this contribution. This contribution also offers the comparison of business requirements on information technology experts, as have been identified by companies in the Czech Republic, to data from higher education institutions in informatics area.

1 Introduction

Massive investments into Information Systems/Information and Communications Technologies (IS/ICT) in last twenty years started economic growth. But not all of them were successful – for example the dot com boom in 90s and its intensive reduction on begin of the 21 century. There are different opinions in the world literature, how IS/ICT influence nominates real economic growth and how to measure their contributions to it [1], [3]. IS/ICT of specific properties are very similar to utilities [2]. But the most important and crucial factor of IS/ICT improvement is human resources actually available and applicable on the market.

This contribution deals with real results of survey realized during years 2006 - 2007 in the Czech Republic by Faculty of Informatics and Statistics of the University of Economics, Prague and it offers short overview of Czech perspectives in requirements on ICT experts and of ICT formal education system.

2 Problem Formulation

The aim of this survey was to motivate universities and to formulate recommendations for further development of the Czech tertiary education in the area of ICT. Requirements for skills and knowledge of ICT graduates are permanently changing. Building up and to passing the accreditation process of a new study program takes in minimum one year, of course, only under conditions that the school or university has enough experts in required areas (guarantors of courses).

3 Survey Description

As a reaction to the low flexibility of the Czech Republic formal education system in the area ICT skills and also to the potential threat from non-ICT university study programs, the Faculty of Informatics and Statistics decided to initiate a research project in order to map:

- ICT education offered in the Czech Republic.
- Demand for ICT skills in the Czech Republic.

The main goal of the survey was to:

- identify at all universities and high schools, which are involved in ICT education, topics of their education process with credits donation of each knowledge category,

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- identify the actual number of students, expected number of graduates in the actual school year and the actual number of new students in the first study year.

The aim of this project is to repeat this investigation (annually or each second year) and on the base of these results to make forecast of new study programs and courses and to manage existing ones.
In the second plan is regularly to investigate the skills requirements for ICT graduates in the Czech Republic market. The survey has been started in September, 2006 and in April 2007 we have got first preliminary results. Requirements are compared based on the same "knowledge" map as was used for universities.
Part of this project was devoted to the analysis of current IT workforce age and skill structure.

4 Methodology

4.1 Roles in ICT – General Concept

The survey prefers classification of specific roles in ICT (rather then particular professions which are in this context too detailed) underlining the competitive ability of graduates based on their knowledge potential. ICT specialist in this context is educated and qualified to use his/her knowledge potential mainly in the design, implementation and operation of ICT and their practical application. We can describe his/her competencies as follows:

- Designs and develops ICT.
- Designs and develops ICT applications.
- Implements, customizes and integrates ICT applications within enterprise or other economic subject, thus changing and modifying working procedures and effectiveness of staff [9].
- Implements and manages ICT operation including user application support.
- Manages ICT projects.
- Manages information services and knowledge provision.
- Provides and purchases ICT services and products – using professional skills regarding detailed knowledge and effective methods of their use.

End users of ICT are not (for the purpose of this survey) considered as ICT specialists, even though most of the current university graduates (medical doctors, financiers, architects) are by definition active in data processing and computer aided operations. We decided to exclude this category because it does not require specific ICT education. For example, a user of SAP is according to our classification not an ICT specialist, but the methodology designer responsible for the overall SAP architecture is covered by our role definitions.

Due to fast developments and relatively high specialization in the area of ICT we have decided to define specialists at two levels – the first level consists of core ICT roles with corresponding key knowledge and activities. This level is relevant for our research because it concentrates on the core competencies and procedures rather then on the detailed technical knowledge which universities could not provide in up to date manner. Second level lists ICT professions included in the core roles (Business Process Analyst/Designer, IS/ICT Development and Operation Manager, Business Person in ICT Products and Services, Developer/IS Architect, Administrator of Applications and of ICT Infrastructure). Furthermore are some obligatory skills that are required for all ICT roles in Czech economy (our hypothesis is that are required in all modern economies):

- high level of creativity,
- team work ability,
- communication competence,
- fluent spoken and written foreign language in majority English or German (for some specific areas also Spanish, Russian or other language – for example Chinese).

4.2 Skill Categories

We have been concentrating on the 18 skill categories (based, but not limited to the respected IT curricula – Strawman curricula [8]) and their weight in the university graduate or employee profile.

We have identified following skills categories - Process Modelling, Application Functionality, ICT Service Definition and Operation, Architecture Analysis and Design, Software Engineering, Data Engineering, ICT Infrastructure, Operational Excellence, Communication and Presentation Skills, Team Leadership Skills, ICT Market Knowledge, Organizational Management Methods, Enterprise Finance and Economics, Sales and Marketing, Statistics, Law, Business Sectors and Other – further not specified skills.

4.3 Knowledge Levels

In order to compare the "amount" of knowledge devoted to each skill category by university program we have defined non-linear scale as following:

- **Level 0** No knowledge.
- **Level 1** Overview (relevant to 1-3 credits or intensive training days).
- **Level 2** Basic orientation and terminology (relevant to 4-8 credits or intensive training days).
- **Level 3** Good orientation and basic practical skills (relevant to 9-32 credits or intensive training days).
- **Level 4** Good orientation and good practical skills (relevant to 33-64 credits or intensive training days).
- **Level 5** Highest knowledge quality and advanced practical skills (relevant to 65 and more credits or intensive training days).

After long discussions with universities and business we have decided to compare (and express) one credit of university study program by one intensive training day, because not all the businesses were familiar with the university credit scheme.

4.4 Knowledge Profiles and Their Distances

Set of knowledge levels for each of the skill categories is in our research defined as "knowledge profile" and is used to compare the requirements of business with the supply of universities.
We have analyzed the distance between the knowledge profiles in our research. Distance between university knowledge profile A and business knowledge profile B is expressed by the number of additional intensive training days required for the graduate with knowledge profile A in order to fulfil the minimal requirements of profile B. The smaller the distance is, the "cheaper" is the graduate of university for the relevant ICT role in business.

4.5 General Scheme of the Survey

Survey and data collection were preformed in two main streams in:

- Higher Education Institutions (HEIs),
- business units in the Czech Republic.

4.5.1 Survey among Universities and HEIs

The surveyed population:
All faculties and HEIs providing IT related study programs based on evidence of the Czech Ministry of Education. There were 54 faculties and 19 HEIs identified in that evidence on begin of the year 2006.
Questionnaire was sent out to all these subjects. They were asked to fill this questionnaire for each IT related study program they provide. Response rate was 81% for faculties and 42% for HEIs. We have collected the data about 203 IT related study programs.
Method of sampling from the population:
Therefore we have surveyed the whole population no sampling method had to be used. Missing quantitative data (number of enrolled, number of students, number of graduates) from non response we have reconstructed from the official resources of the Czech Ministry of Education. Missing qualitative data (number of credits devoted to each skill category) were not reconstructed and these faculties and HEIs institutions were included into final results as "not classified" segment.
Variables

a) Number of students, number of enrolled (new entrants to the study program each year) number of graduates in the school years 2000 to 2006 and expected numbers for some following years.
b) Number of credits devoted to each of 18 skill categories defined.
c) Classification variable: level of study program – HEI, bachelor (3 years), master (2 years), master (5 years; these are the "pre Bologna" programs ending in 2006 or 2007 school years)

4.5.2 Survey among Business Sector

The surveyed population:
all active economic subjects in the Czech Republic on 2005/12/31 (the survey was held in 2006). According to data of the Czech Statistical Office, there were 1 266 336 subjects of various size and main economic activity (Table 2).
Size of entity: According to the number of employees, 6 categories were used: 0, 1 – 9, 10 – 49, 50 – 249, 250 – 999, 1000 and more.
Sector of main economic activity: There are 17 main sectors in Industrial Classification of Economic Activities of the Czech Statistical Office. According to the requirements on information technologies, these sectors were coded into 3 categories: sectors with the lowest requirements (MIT), sectors with the middle requirements (SIT) and sectors with the highest requirements (VIT).

Table 1 All active economic entities in the Czech Republic on 2005/12/31

	0	1 - 9	10 – 49	50 – 249	250 – 999	1000 +	Total
MIT	263 289	49 914	14 270	4 317	369	87	**332 246**
SIT	697 380	138 555	28 014	6 217	1 164	182	**871 512**
VIT	49 851	9 590	2 216	710	170	41	**62 578**
Total	**1010 520**	**198 059**	**44 500**	**11 244**	**1 703**	**310**	**1266 336**

Method of sampling from the population: According to the size of subject and to the category of its economic activity, the population was grouped into 18 subpopulations. Then, stratified sampling was applied. Proportionate allocation when the sampling fraction in each of the strata is proportional to that of the total population was not useful here. There are no homogenous subgroups in the population. As we can see in Table 1, their size is very varied. Because of number of employees the variation of number of IT workers in subject certainly is very heterogeneous, too. Optimum allocation requires knowledge of this variability (it was un-known). So, we took this heterogeneity into account at least in the following way: the sampling fraction was higher in strata with more employees and in sectors with the higher requirements on information technologies.
The interviewing methods used were CAWI and CATI. Realized sample size was 1002 (Table 2).

Table 2: Structure of the observed sample

	0	1 – 9	10 – 49	50 – 249	250 - 999	1000+	Total
MIT	56	28	28	28	37	16	**193**
SIT	56	56	56	56	71	36	**331**
VIT	56	110	160	122	26	4	**478**
Total	**168**	**194**	**244**	**206**	**134**	**56**	**1 002**

Variables
a) Number of IT employees in 2006 in the following structure: business analyst, IT manager, IT salesman, architect of information networks, administrator, advanced user. Expected number of IT workers for some following years.
b) Knowledge requirements on particular professional positions: there were 18 skill categories defined (thus, 18 ordinal variables with values 0 – "no knowledge (0 training days)" … 5 – "highest knowledge (more than 65 training days) ".

c) Classification variables: number of employees, sector of main economic activity, requirements of the sector on information technologies, IT supplier or customer, national or exterior owner.

Number of IT employees:

Sample distributions in the particular strata are highly right skewed (duly incidentally) and they include outliers (the box plots were used to make the explanatory data analysis). Therefore, to characterize their location and variation, and for estimates of total number of IT employees in Czech economy, medians and median absolute deviations were used. In the stratum "entities without employees", the proportion of "IT entities" in that stratum in population was estimated.

Knowledge requirements:

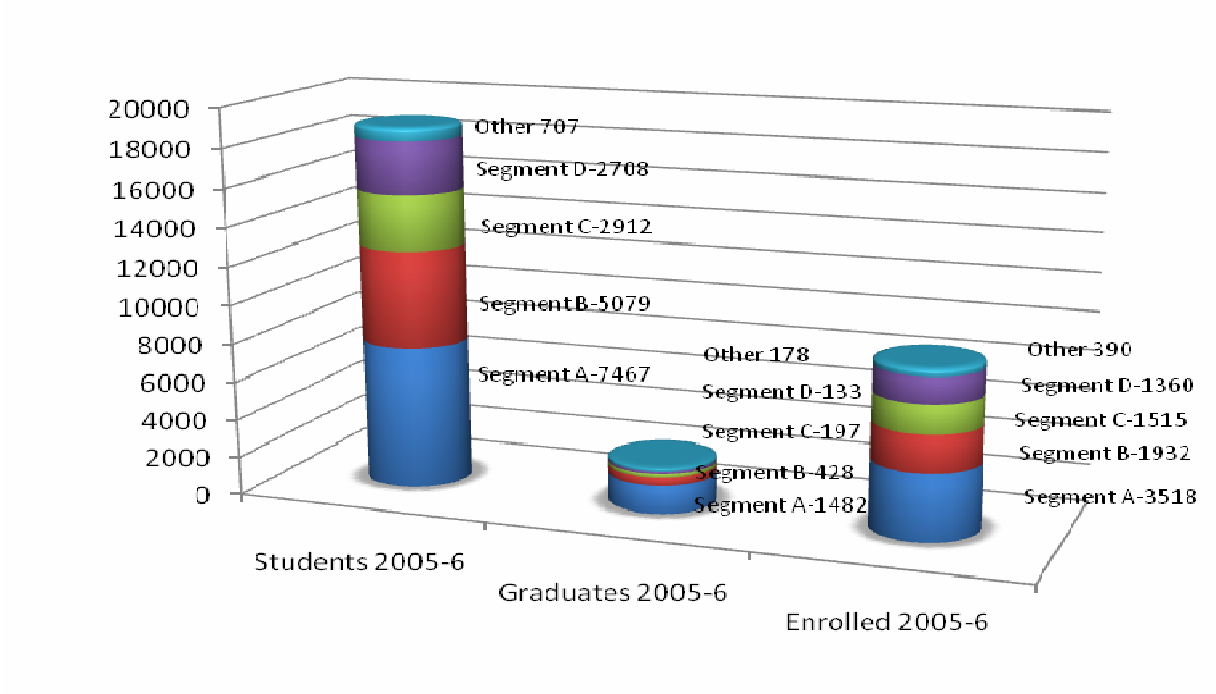
With respect to nature of variables, medians were used again. To compare different professional positions and different skill categories, box plots (for sampling distributions) and scatter plots (for medians) were used.

5 Results Overview

We present, due to its limited scope, only the general results of the survey – analysis of the Czech Republic ICT education market and basic results from business survey in this paper. The most important part of this research is the characteristics of the study program segments (clusters) which are showing very interesting results.

5.1 Bachelor Level Education

Grafh 1 Bachelor Studies Segmentation (With Number of Students, Graduates and Enrolled)



Segment A – indicates characteristics with **very low level of ICT education** (work hypothesis is that ICT education is "additional" to other ones). This low level could be investigated in two dimensions. The first dimension is the variety of the ICT courses, which are focused mainly on software engineering, data engineering and ICT infrastructure without any other knowledge for students. This selected part of ICT gives to graduate students only briefly overview of the business oriented ICT and general information about it. The second dimension is the depth of the education in selected course. Level three is very low for

teaching so low variety of courses. The level is below the average of the whole ICT education level through all investigated segments.

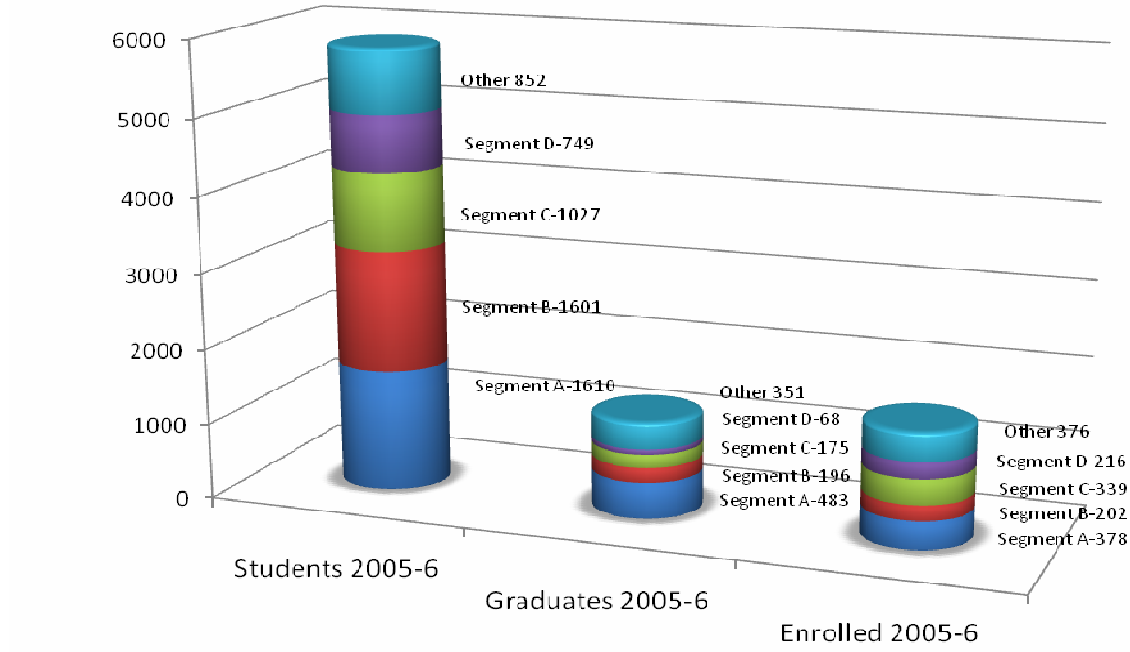
Segment B – offers **harmonic education in "exact sciences"**. Education is focused on ICT area presentation with added value of the statistics, marketing and enterprise finance and economics. This specialization gives perspective to a graduate either to be a lower ICT manager to go to further master study level.

Segment C – gives **common education in classic ICT**. This kind of education represents knowledge in areas of ICT services, software engineering, data engineering and ICT infrastructure, operational excellence, communications and team leadership. Additional is taught statistics – part of "exact science". These graduates have potential for being successful ICT managers especially the top ICT managers on the CIO level.

Segment D – the most **complex knowledge with emphasis not only to ICT education**, but it releases also general education in economics, organization and enterprise knowledge. The D segment with whole scope of taught knowledge offers potential for future graduates to enter into the level of upper management and perhaps to the top management level. Knowledge here presented must be, of course, supported by very strong motivation, further education in master level (perhaps in doctor stage) and hard work in business.

5.2 Master Level Education

Graph 2 Master Studies Segmentation (With Number of Students, Graduates and Enrolled)



Segment A - ICT Additional (ICT overview) gives only general partial knowledge level in the ICT area. The ICT level is only additional to other non informatics education and it is question why are these master programs taught in the community of ICT specializations. Graduates are expected to continue in ICT education. Working hypothesis is that these persons could participate in ICT business in following roles Business Person in ICT products and services (ICT Sales Person, ICT Relationship Manager).

Segment B – offers comprehensive basic education in ICT. For graduates is working hypothesis that they have opportunity to, of course after further business – non university –education, enter successful into ICT business in all specified roles.

Segment C – prepares graduates with accent to Architecture Analysis and Design, Software Engineering and management skills – Communication and Presentation, Organizational Management Methods. Working hypothesis is that graduates are ideal for leading positions in ICT branch. It could be the large spectrum of professions starting from project managers to the CIO. This expectation corresponds to the role IS/ICT development and operation manager (ICT Manager).
Segment D – gives more detail knowledge in areas of Process Modelling, ICT Infrastructure and Software engineering. Work hypothesis is that graduates in this segment are oriented towards following roles - Business Process Analyst/Designer or Developer/IS Architect.

5.3 Business Sector

In previous chapters, we have described how we have been analyzing the distance between the knowledge profiles of university programs and business requirements for the particular business role. Let us discuss the example of such analysis for the Business Process Analyst/Designer ICT role. Requirements for this role are described at the Graph 3.
Note: numbers 0-5 on each axis represent knowledge level scale values. Interpretation is in this case that e.g. business requires knowledge level 4 (Good orientation and good practical skills) in MS01 Process modeling skill category for new employees in the Business Process Analyst/Designer ICT role.

Graph 3 Knowledge Profile of the Business Requirements for the Business Process Analyst/Designer ICT Role [5]

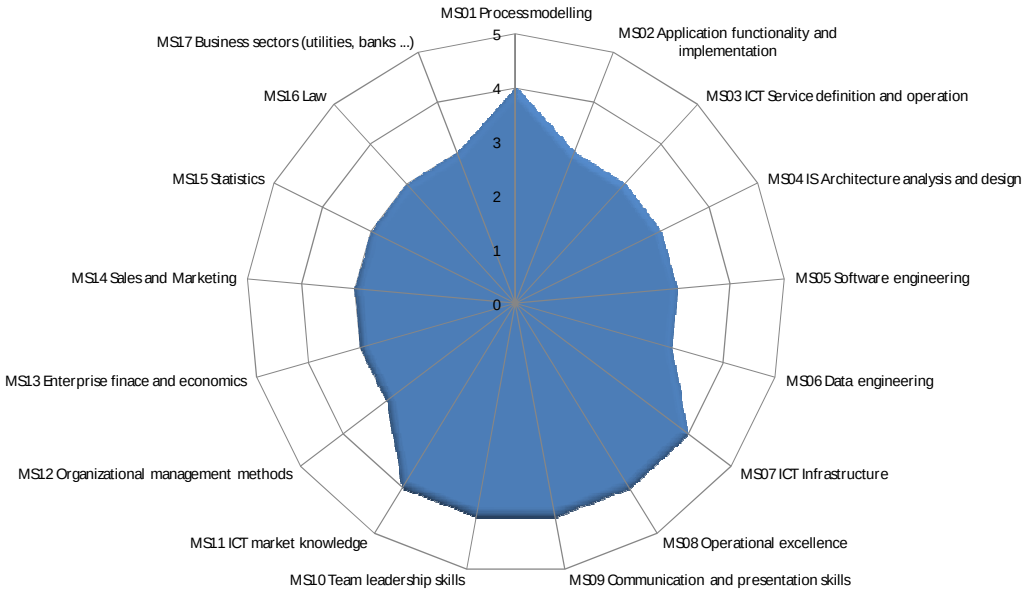


Table 3 Distance Among the Bachelor Level Programs and Business Requirements for the Business Process Analyst/Designer ICT Role (Graph 1, Graph 3)

Bachelor level programs segment name	Distance (in number of required additional training days)	Number of Students in school year 2005/6	Number of Enrolled in school year 2005/6	Number of Graduates in school year 2005/6
BcVos - Segment A	**146**	5027	1861	714

BcVos – Segment B	**109**	2280	1121	188
BcVos - Segment C	**114**	2720	1178	343
BcVos – Segment D	**68**	3084	1526	237
BcVOS not classified – Others		3848	2211	726
Total		**16959**	**7897**	**2208**

Distance (expressed in the number of additionally required intensive training days) among the master level programs and business requirements for the Business Process Analyst/Designer ICT role (Graph 3) is depicted in the Table 4.

Table 4 Distance Among the Master Level Programs and Business Requirements for the Business Process Analyst/Designer ICT Role (Graph 2, Graph 3)

Master level programs segment name	Distance (in number of required additional training days)	Number of Students in school year 2005/6	Number of Enrolled in school year 2005/6	Number of Graduates in school year 2005/6
Mgr5 – Segment A	**155**	1610	378	483
Mgr5 – Segment B	**59**	1601	202	196
Mgr5 – Segment C	**40**	1027	339	175
Mgr5 – Segment D	**42**	749	216	68
Mgr5 not classified - Others		852	376	351
Total		**5839**	**1511**	**1273**

6 Conclusions

General strategic results of our survey are to:

- build up of facilities for regularly (annually or each second year) investigation and monitoring:
- ICT oriented study programs and courses,
- business requirements for knowledge of ICT graduates (bachelor and master),
- forecast needs in new study programs and courses in the area of ICT.

After analyzing results in the way as presented in Table 1 and Table 2 for all ICT roles defined in this project, we came to the following interesting conclusions.

- ICT oriented study programs significantly differ in the level of knowledge provided in comparison with the business requirements. Even though all the surveyed study programs were defined and presented as IT related, there is a big difference among them. E.g. graduate of BcVos A segment study program requires 78 extra training days in comparison to graduate of BcVos D segment to start in Business Process Analyst/Designer ICT Role. In total graduate of BcVos A segment (32% of all graduates) requires 146 extra training days which makes him/her absolutely uncompetitive at the IT labor market.
- There is no direct relationship between the specific study program and specific ICT role. Some study programs form excellent background for any of the defined ITC roles, others are not useful for any of the defined roles.
- Graduate bachelors in the Czech Republic do not have in majority of cases (at about 85%) appropriate knowledge profile to enter business as qualified employees (especially in Business Process Analyst/Designer, Developer/IS Architect, IS/ICT development and operation manager) without additional training. They are too “expensive” in terms of further education in companies. Bachelor programs are nowadays in fact formulated not as standalone, but rather as prerequisites of the Master studies. Related conclusions we have found in South Africa conditions [7].

- Situation is better for graduates of Master studies where "only" at about 40% is not competitive and not able to enter the IT market without extensive training.
- It is time to start restructuring of higher education system especially in ICT education in the Czech Republic. It must be realized by opening of new study programs in ICT, which have to offer multi-, trans- and interdisciplinary presentation of knowledge.

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