

Engineering education promotion and e-government

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ABSTRACT: The popularity of engineering and science education has been falling down. Many global firms, however, complain that there is a strong lack of highly qualified technicians. Czech authorities point out that it could be the reason of investments boom termination in the Czech Republic in the next future. The shift of factories to the East need not be caused only by cheap labor in the East but also its quality. Many young people due to missing information and various fashions believe that the best perspectives have humanities. Many students improperly believe that there is unlimited number of good jobs for top managers, lawyers, political scientists, artists and so on and that technical education is boring difficult and have no prospects. This false believes can be avoided by detailed information on the job market obtainable from e-government systems. There are, however, many organizational and legislative barriers. The solution is based on service oriented software architectures of e-government, the measures increasing data quality and the principles of the integration of applications presenting information. Crucial requirement is that the quality dimensions of information must be evaluated to a high degree separately from the aspects of data quality. This fact must be taken into account in legislative.

INTRODUCTION

The popularity of engineering and science education has been falling down - at least in the developed countries – during the last several decades. According to several studies only about 11 per cent of undergraduate students are studying technical areas in USA. Similar trends can be seen in Europe.

It is to some degree a response to the fact, that many attractive jobs have been created in services. The jobs often require knowledge of humanities. The study of humanities is cheaper for schools (no labs, few tools, etc.) and easier for many students.

On the other hand many global firms complain that there is a strong lack of highly qualified technicians and that it is the main barrier of their growth. Czech authorities point out that it could be the reason of investments boom termination in the Czech Republic in the near future. The moving of factories to the East can be the move not only to the areas where labor is cheap but also where there is enough of qualified engineers.

On the other hand the growing complexity and sophistication of modern technical systems and growing complexity of their use, those applied in services inclusive, require a growing quality and extend of engineering knowledge of the people selling using and maintaining the. Experiences with information systems (compare the practices for information systems requirements specification) indicate that it might be easier to teach information technology experts necessary knowledge of humanities than teach people with no technical training basics of information technologies.

The problem is that many young people due to missing information and various fashions believe that the best perspectives have humanities only. Due improper judgments students believe that there are an unlimited number of good jobs for top managers, lawyers, political scientists, artists and so on.

The data allowing to obtain a complex and detailed information on the job market exist in e-government systems. But they are inaccessible as there are many organizational and especially legislative barriers.

Many engineering professions [20] as well as commercial jobs require multidomain knowledge. It typical for software engineers who need to specify requirements together with users as well as for businessmen needing to understand technical properties of the products they buy or sell.

The school systems in many countries undertake substantial restructuring. Many variants of educations are allowed. The teaching of science and mathematics is often substantially reduced. The two-degree system (bachelor/master) university study is generally accepted. The whole system becomes more and more dynamics, but feedback allowing to evaluate the effects of the changes is not strengthened. Many education experiments are not in fact properly evaluated. Such systems tend to be instable. In any case the whole system is not properly tested and it is definitely not any good message especially in current globalized world.

We show some ways, how to increase tool allowing to limit subjective wrongly designed changes in school systems and to provide young people information enabling them to make well founded decisions. The solution is based on the information that can be provided current e-commerce systems on service oriented software architectures, measures increasing data quality and the principles of the integration of applications presenting information. Crucial requirement is that the quality dimensions of information must be evaluated to a high degree separately from the aspects of data quality. This fact must be taken into account in the legislative.

CHANGES OF EDUCATION SYSTEMS

Education is considered to be a crucial factor of competitiveness of nations and economies in a globalized

word. The governments support the modernization of schools and school systems. In the Czech Republic more reforms were accomplished during the last 20 years than in the two preceding centuries. Many alternative programs and variant types of education were introduced on the basic and high schools (primary and secondary education). At universities the two-level system (bachelors and masters) was applied.

The extent of mathematical, science and technical subjects has been reduced, the education of knowledge has been emphasized and skills training have been reduced too. Are all these changes the steps in the right way? There are reasons for disbeliefs.

Global enterprises feel the shortage of highly qualified experts in business and especially in technical professions (see [9]).

The reason of the formidable shift of production, development, and research (US researchers are afraid of competitors) to Asia need not be the cheap labor force but the sufficiency of highly qualified manpower of suitable professional profile.

Unemployment is a serious problem. Not speaking about the fact that there is only limited timely evidence how the chance to get a job depends on education of certain type. It is important to know what knowledge is the need for graduates from individual schools and individual disciplines and what the need will be in the future.

The success of individual school alumni is studied by a lot of institutions. The quality of such research is strongly limited by the fact that the effects of individual steps and changes in the scholar system is not sufficiently compared with real effects in practice (e.g. by a level of success of graduates and alumni on the labor market). The problem is even more severe in Czech republic and similar countries. It opens free space for ill-conceived experiments and for lowering the responsibility of the politicians and education bodies for the changes and quality of education. It also opens a free space for lowering responsibility of young people for the selection of study and career type and reduces the availability of the information needed for a good choice.

In the Czech Republic the number of university students has grown substantially. Almost all faculties and universities founded in Czech Republic in the last five years teach humanities and social sciences. A typical case is a regional university planning to produce 120 masters a year – journalists on economic matters.

Many journalists and artists declared in TV that they were very weak in mathematics they are proud about it.

The main reason is the unavailability of information of school successfulness measured by successfulness of their students. This information can be retrieved from the existing data of *e*-government but it is obstructed by legislative and by the unwillingness to solve the problems.

HOW MUCH OF ENGINEERING EDUCATION

So there are indications that in Europe and the USA the number of graduates in technology was overly reduced. One of the reasons can be the fact that technical knowledge cannot be cheated, it must be exact and supported by firm skills.

It can be also a consequence of the fact that the technical education is expensive compared with some of the most popular education types (lawyers, managers, etc.). Let us compare it with facts.

- According to [9] 40 per cent of large global enterprises feel the lack of highly qualified technicians as a main barrier of their further development.

- In the Czech Republic and especially in Western Europe the shift of production factories to East is felt as a big threat. It appeared now that the reasons are often not the low salaries in the eastern countries but the lack of good engineers in the western ones. It is also the main complaint of large investors in Czech Republic according to the governmental agency Czechinvest. It is stated that the lack of good engineers could cause the end of the investment boom in Czech Republic.
- CIO and the owner of Author company importing bicycles into Czech Republic says that hi-tech bikes must be completely assembled in east Asia. There are no craftsmen in Czech Republic able to do it in the top quality.
- It is quite likely that the similar reasons are behind the fall of US and as well as UK car industry (compare the approaching bankruptcy of General Motors).
- It is doubtful that high production of graduates in humanities and services will be able to support prosperity of Czech Republic. It can be quantified and decided using the information that can be mined from *e*-government. It is, however, not possible yet.

There were many people pointing the risks out. There were no responses as there were words against words only.

The facts were and are not available. We can only say that it is a crucial failure of IT people in *e*-government as well as outside it.

METRICS OF THE QUALITY OF EDUCATION

The evaluation or measurement of the quality of education should be based on metrics easy understandable for public. The metrics should correspond to the intuitive and common understanding what success in fact is. We believe that it is the opportunity to have a well paid and, if possible, also an interesting job or profession.

We therefore should use the level of incomes (salaries, benefits, wages, etc.) provided by a job or by a profession as a measure of the success of the given group of people.

It is desirable to implement an interface allowing viewing the data as data of a virtual database allowing SQL-like queries. Examples of queries:

- What are the salaries of the alumni of a given school or school type and how many unemployed are within them? The salaries can be represented by a frequency diagram or by frequencies or by an average.
- What are the salaries according to professions or profession groups (n years after graduation)?
- What is the probability that a person with a given type of education would be n years after graduation unemployed?
- What is the probability for alumni of a high school that he/she successfully finished the given university?
- What is the correlation between the extent of teaching mathematics at high schools and the success in the career (salary, unemployment)?
- What the unemployment is of graduates (job type/school n years after graduation)?

The data on incomes can be found in tax offices, in the offices of social systems and at office of statistics. Many data on unemployment have labor offices etc. Some data should provide particular schools.

Let us notice that answers to such queries have the character of information that should be accessible for public, the data needed to compute the information are, however, sensitive (not

open to the public). The issue is that such information is in fact treated as secret too.

Using service-oriented architecture (SOA, [12, 13]) it is possible to create an interface (portal) of the system of state administration able to generate from the data of state administration all information that are public (not sensitive) using the interface that interprets the data of state administration as virtual distributed database.

We discovered that the information systems integrated into *e* government of Czech Republic collects and stores all the data required for the answering the above questions. Unfortunately it appeared that it is not possible as the access to the sensitive data is strongly restricted - the data are in fact classified for third party applications and to some degree even for the state administration itself.

One can argue that the situation is specific for Czech Republic only. The facts that the engineers are missing all over the world indicate that the situation is in many countries similar.

DATA QUALITY ISSUES

It appeared during the analysis of the problem that the accuracy and relevance of the information is mostly restricted by of wrong quality of data formats e.g. the formats of addresses of citizens. It is not so critical for some queries leading to answers of statistical character. Accidentally, it is not always true. It is a consequence of the situation when the data maintenance, especially data cleansing, is made improperly.

From the data cleansing operations (exclusion of data having wrong format, format unification, boundary values, "adding" missing data, excluding duplicated data) appeared format unification to be most important.

This issue reduces the usefulness of information as format snags implies undiscovered duplications and makes the identification of some subjects and the searching for the data form certain regions inaccurate/error prone.

It adversely influences the data quality metrics relevancy, validity, and especially comparability. Many problems with formats and identification can be solved using a more or less centralized formats registry.

The registry can be again implemented as a one software service in the sense of SOA or as a network of services. But such a central service behaves like a foreign body in service-oriented SOA systems being virtual p2p networks.

EXCESSIVE DATA PROTECTION AND OTHER LEGISLATIVE BARRIERS

The legal barriers hindering the information mining from *e*-government can be divided into the following two groups:

Data Protection.

There is no sufficiently flexible procedure how to declassify sensitive data for the generation of publishable data to wide enough number of applicants. It is, however, not suitable to let the generation to be the matter of state administration only. Such solution is inflexible, lengthy and too restrictive for the citizens and companies.

Information Protection.

No generally acceptable allowance procedures for the applications able to compute and publish information that is not classified are available yet. Note that the solution assuming that the applications should be developed by the state administration is too inflexible and in fact implies that a lot of information, for example the information on the quality of education, will not be accessible for even.

Current situation in Czech legislative is complicated by the fact that in Czech legislative the position of the offices concerning data protection is too strong. The most powerful are the offices responsible for the protection, especially for the personal data security and protection. These offices, however, have no responsibility not to build any barriers for the generation and accessibility of information open for public. So they generate the barriers. Even worse. The data filtration and cleansing is very limited in the Czech *e*-government.

In other words the current practices in Czech Republic are too oriented to the issues related to a virtual data layer of its *e*-government.

CHANGING STRUCTURE OF ENGINEERING EDUCATION

We have noticed several times that the profiles of engineering professions are changing.

Technical changes include changes in traditional professions like new materials, new construction principles, and new development tools. The changes speed up the knowledge half time diminishes. The changes often generate new professions and changes the knowledge profiles of the traditional ones.

Non-technical knowledge and skills become more and more important. Engineers, especially software engineers, require knowledge enabling detection or specification of user or customers needs. Sellers should know a lot on the technical properties of the product they sell. So there must be many engineers having multidisciplinary knowledge. The curricula must be modified accordingly. The need to change education can be detected by the evaluation system of education quality.

The evaluation system should be designed as open as it must gradually collaborate with many systems – *e*-commerce software, labor offices, personal agencies, bodies studying the economical processes etc. The functions of the crucial kernel of the system must use the support of *e*-government as it has the most complete and most timely data.

The existing data can support a more general and powerful analysis like time series analysis on the level higher than in the systems of business intelligence as almost all the data mentioned above are stored for many years a they therefore can be used in data series analysis. The need to change the structure and content of education should be detectable by the system of the evaluation of the quality of education.

SOME TECHNICAL ISSUES

Information computation and presentation should be technically as well as organizationally and in the software architecture separated from the data collection, cleaning, and maintenance.

The aim should be that citizens, enterprises, politicians, and offices will have access to all information allowed to be accessible for them provided they can be mined from the data of *e*-government and other sources (e.g. personal agencies, schools etc).

Such a requirement is feasible if the software supporting *e*-government is service oriented, has a service-oriented architecture, and the information is mined and presented by dedicated applications (information application – IA).

Such a solution is possible only under specific technical conditions (application of the service-oriented philosophy and presence of people able to apply it) and political will (IA is allowed to be a service; the only condition is that it cannot

disclose "secret information"; there are certification procedures).

The information applications (IA) should be certified by a certification authority for the integration into *e-government* system. The certification should include testing and source code inspection. The outputs of the application should be logged to be possible to test that the application did not produce closed information. The application should reside on a trusted server. The system should be open to be able to communicate with third party systems providing some further data of using the information produced by IA's. We believe that the data from the *e-government* are the most useful ones. They are up to date, tend to be of standard quality and there is a chance that under a good legislative they will be accessible. Modern software architectures enable to virtually integrate the data from *e-government* and from other sources.

CONCLUSIONS

The main issue with education systems is that we have no good feedback about its quality and about the effect of various reform of the education system. The education system should be evaluated and controlled in a way comparable with the evaluation of business systems. The proper use of data of *e-government* can enable it.

Such an evaluation is good not only for technical professions. We believe, however, that for the reasons discussed above, engineering education will have the greatest benefit from it as there are many prejudices against engineering (and scientific) education and the prejudices can be avoided only via presenting convicting facts. The evaluation can make solvable such questions like how to design the structure the education highly qualified craftsmen or what is the optimal ratio between learning knowledge and training skills. Note that mathematics also trains skills!

There are barriers. The legislative barriers were discussed above. Engineers and teachers should fight for the changes in legislative such that it opens data from *e-commerce* for public use for production information. It is a task that the teachers do not love. There can be resistance from schools not able to response in a proper way. It is crucial challenge for information technologies a great opportunity for modern society.

If a government says that education is important it must also invest into education and at universities into research. It must also make a proper „marketing“. It is crucial that the government agree to invest into the development and the use of education quality evaluation systems and procedures in order to build a system depending on subjective judgments and volatile fashions as little as possible.

We have proposed the way to achieve it. Note that pre proposed solution and tools are technical products. It is yet another argument in favor of engineering (technology oriented) education and engineering attitudes in general.

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