SPREADSHEET ENGINEERING EDUCATION: HOW TO IMPROVE IT? CASE OF SERBIA

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Abstract
Spreadsheets are becoming increasingly important in many companies. They are suitable to be applied in various business tasks. Thus, it is important to provide appropriate trainings and courses. Many educational institutions recognized the importance of spreadsheets by including in the curricula of their programs. Therefore, authors examined the current spreadsheet state in Serbia. We analyzed the sources of this type of education, and examined the amount and area of spreadsheet usage and quality of provided spreadsheet knowledge. The results show that this tool is applicable in almost every functional area of company and that the main sources of spreadsheet education are higher education institutions. However, the quality of the knowledge is not on the expected level. These results represent an initial effort to identify the directions for curricula improvement, intended for future research.

Keywords: Engineering education, spreadsheets, spreadsheet education, education tools, business compentences

JEL Classification: I21, I23, M21

Introduction

Spreadsheets have become widely accepted and necessary for the functioning of many companies since they were first introduced into practice. Spreadsheets are used in everyday tasks and they are an important analytic tool in the modern business world. They are used for office tasks, modelling, analysis, forecasting, decision-making etc. Spreadsheet programs have found their application in a wide range of organizational functions in various fields of industry for the achievement of business goals. Spreadsheet end-users work in a variety of business functions: finance, engineering, manufacturing, marketing, sales, administration, etc. (Baker, 2006). Spreadsheets are one of the most powerful tools for analysing data, and it's widely available. Both large corporations and small companies use spreadsheet models to determine their current key performance measures, and where they are expected to be. But, in order to get the most out of a spreadsheet, users have to know how to use it. Consequently, spreadsheets are indispensable part of many educational

courses and commercial trainings. Corporate recruiters from all business functional areas consider that spreadsheet skills are invaluable and demand those skills when hiring employees (Leong, 2008). Therefore, it is worthwhile to examine how well spreadsheets courses are designed and is it possible to identify how to improve them.
Mass-market spreadsheet trainings and books or introductory spreadsheet courses in schools and faculties are not enough, because those sources don't provide the context needed to learn spreadsheet engineering and management topics. Business context is essential to learning these vital spreadsheet abilities.
Although there is trend of measuring academic performance of higher-education institution programmes (Aleca and Mihai, 2016), there are no researches which focus on spreadsheet engineering education. Thus, in this paper, we present the results of the practice research we conducted for determining the usage of spreadsheets in Serbian companies. The aim of the research was firstly to identify how much spreadsheets are used in the practice, and secondly to discover which type of education is the primary source of this knowledge. Also, the goal of the research was to discover the level of spreadsheet knowledge used in these companies, and identify the directions for improvement of spreadsheet engineering education.

Spreadsheets in education

Spreadsheets represent a group of application packages used for table-based calculation (Oke, 2004). Spreadsheets are inexpensive, runs on machines of modest specification, and they are widely available not only to professional engineers but also to learners at universities, colleges and schools, as part of the general information technology education. According to (Oke, 2004) the use of spreadsheets for engineering purposes enables tasks to be completed more efficiently, and often achieves a higher degree of accuracy than humans do. Spreadsheets offer flexibility, ease of use, and application creation with the ability of complex data analysis. Also, spreadsheets are the cheapest tool in comparison to other software applications. Despite the advantages and frequency of spreadsheet use, one of the main problems is the lack of adequate training and education (Alliy and Brown, 2008).
In the field of education, spreadsheets can be utilized in many different ways. Spreadsheets usage reduces the need for tedious calculations allowing greater attention to be focused on the subject itself. This feature of spreadsheets can be used in many different disciplines across the curriculum. For example, handling sizable amounts of numerical data makes it difficult to concentrate on the subject matter in mathematics. The students should be given the opportunity to design and develop their own templates in each content area, and also to use the devices to solve problems and make decisions on the basis of quantified evidence. To achieve these objectives, spreadsheets are recommended, since they are believed to be capable of solving almost any problem involving numbers or formulas, and are especially powerful if data is to be used repetitively and changes over time (Djordjević and Vasiljevic, 2013). Spreadsheets can be tool for motivating students. Students can model problems by themselves quickly, in that way understanding of problems is easies, and very important, students can see result of their work in the short time.
The history of spreadsheet application in education started with finance and accounting fields (Power, 2004). In further development, application of spreadsheets was extended to engineering education. For example, present level of spreadsheet awareness in electrical engineering education is high, due to their insight, interest, foresight, and extensive applications of the package to electrical engineering problems. According to (Oke, 2004),

spreadsheets are virtually everywhere in the today's engineering field: from elementary numerical analysis in general engineering to quality control in software, from cache based parallel processing systems in electrical.
Spreadsheets provide broad possibilities of creating simulation models for educational purposes. Spreadsheet models are suitable for logistics, business management, operations research, operations management and other studies (Djordjevic and Vasiljevic, 2013). The basic spreadsheet features facilitate static and dynamic simulations, and can be rather effective and helpful in different areas of application. The spreadsheet simulation models can be used as a platform for understanding the mechanisms behind the discrete event, as well as system dynamics approaches. They have advantages of getting software skills in a short period of time, broad availability, ease of use, ease of validation, and low price (Robinson, 2004). It is possible to implement both static and dynamic simulation using spreadsheet standard functions only. Macros and add-ins as simulation engines give an additional support to model construction and replication of simulation experiments. Understanding of simulation models by using spreadsheet can be a basis for understanding business dynamic, for practical investigations or for further shifting to special software (Djordjevic and Vasiljevic, 2013).
Spreadsheet engineering is needful part of business school management science courses. Spreadsheet engineering education can be represented as a hierarchical model (Figure no.1), where levels are: skills, capabilities and practices.

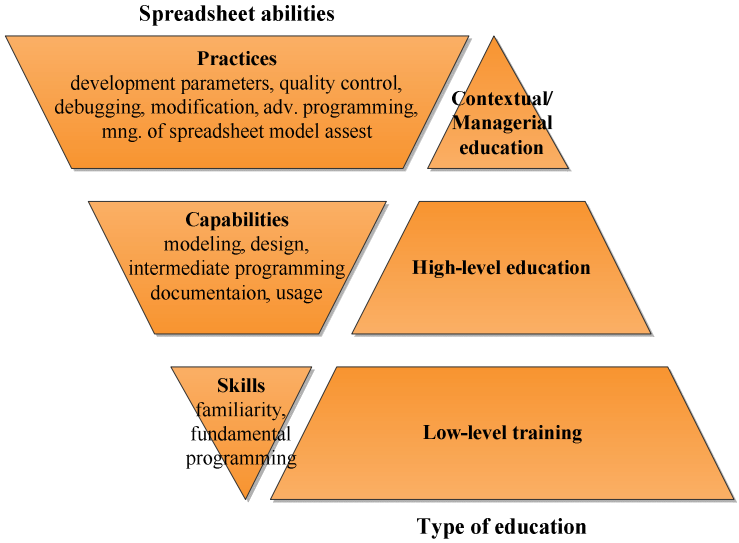

Figure no. 1: Spreadsheet engineering education hierarchical model

"Low-level" skills need to be evaluated and fixed early in a spreadsheet oriented management science course. High-level "Capabilities" and "Practices" should be integrated throughout the course (Grossman, 2006). According to Grossman (2006), "People aren't getting what they need from mass-market spreadsheet training books or in their introductory spreadsheet training class because those sources don't provide the context needed to learn spreadsheet engineering capabilities and practices. Faculties must

thoughtfully choose which spreadsheet skills, capabilities and practices they incorporate into their course. They may choose to reduce the quantity of traditional management science topics in order to develop the essential spreadsheet engineering foundation for actual usage of management science. Instructors have many choices to make regarding spreadsheet skills, capabilities and practices. These choices depend on the goals of the school, program, and students, as well as the type of work the graduates will engage in. Different choices will be appropriate in different settings."

Research description

In order to identify the necessity for improvement directions of spreadsheet engineering education in Serbia it was justified to investigate the practical view of spreadsheet usage. For that purpose, we conducted the research which examined the usage of spreadsheet tool, the main education sources, and the main fields of application.

The questionnaire used to collect data on spreadsheet users' characteristics considers seven-phase model of spreadsheet evolution. Phases of the model are: design, testing, documentation, usage, modification, sharing and archiving (Lawson et al. 2009). In accordance with a questionnaire design, defined questions allow determination of users' attributes for seven phases of the spreadsheet evolution model. Besides questions related to spreadsheet evolution model, the survey contains questions pertaining to training, quality control and risk associated with the use of spreadsheets. Questions are closed-ended. The research population consists of spreadsheet users who are employed at companies from various fields of business and functional areas. The survey was conducted in Serbia in year 2015/2016. The research was anonymous. The sample consists of 165 respondents, employees at 15 different companies. For the purpose of this paper we extracted the set of 94 respondents, with bachelor degree. The population was selected as group which is the most representative for the purpose of this research.

Results of the research

In order to examine the sample from the perspective of spreadsheet familiarity, we analyzed the level and sources of spreadsheet education. According to the results (Figure 2), it can be concluded that the major part (78%) of respondents has some spreadsheet knowledge. Additionally, the main source of that knowledge is university courses (formal education sources – 42%).

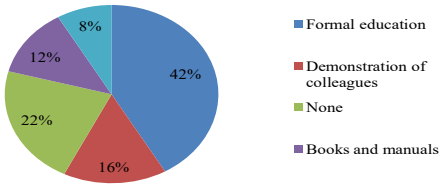

Figure no. 2: The structure of spreadsheet education sources

But further, it was necessary to examine the field of application and the usage in daily business activities. For that purpose, we excluded the respondents with no spreadsheet knowledge ("None"), and performed analysis on the remaining 75 respondents. The respondents were also asked to mark the average amount of time engaged in working with spreadsheets. The most of them (41%) are using 0-25% of their time, while 31% of respondents are using it 26-50% of time. Cross-analyzing the education sources and the amount of time working with spreadsheets showed that regardless frequency of use, the main source of education remains the same – formal education (Figure no. 3).

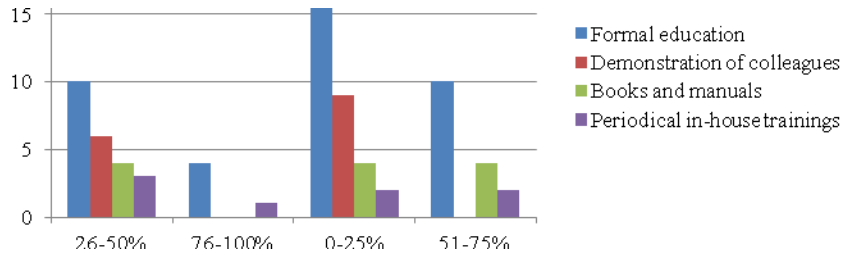

Figure no. 3: Cross-analyse of spreadsheet education sources and spreadsheet business usage

Analyse of functional areas (or field of application) also indicates that the dominant source of spreadsheet education is university (Figure 4), which also highlights the necessity for integration of spreadsheet engineering and domain knowledge though faculty courses.

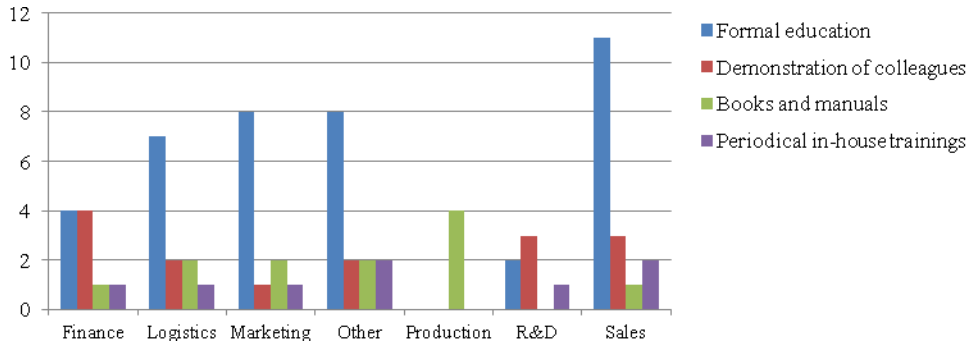

Figure 4: Cross-analysis of spreadsheet education sources and field of application

Although the dominance of formal education in the area of spreadsheet engineering is evident, that does not imply that the highest level of skills origin from this type of education. Even though university courses play the mail role in spreadsheet education, survey showed that they provide mostly low or medium quality abilities (Figure no. 5). Moreover, significant number of respondents estimated their knowledge as "low" originated from formal education sources. In accordance with Grossmans' model

(Grossman, 2006) shown in Figure 1, it would be expected that respondents with bachelor degree are mainly grouped as "medium". Thus, in the context of curricula, survey results confirm already recognized necessity of introducing spreadsheet engineering topics to appropriate courses.

Based on Grossman (2006), low-level spreadsheet training should be introduced in the education before faculty level. Low-level training considers spreadsheet basics (starting and opening spreadsheet, understand concepts of cells and regions, worksheets, sheet tabs and cell referencing) and fundamental programming (creating and editing formulas; the most common functions; absolute and relative references; simple formatting; cutting, copying, and pasting).

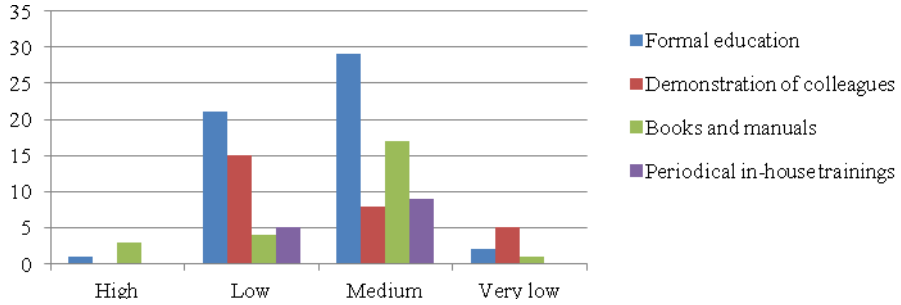

Figure no. 5: Cross-analysis of spredsheet education sources and the level of spreadsheet abilities

Beside spreadsheet basics and fundamental programming, job requirements consider higher spreadsheet education level. Higher spreadsheet education level includes modelling, design, intermediate programming, documentation and usage (Grossman, 2006). As mentioned, the dominant level of knowledge is classified as "low" and "medium". Lack of spreadsheet knowledge can be attributed to the gaps in faculty education, if they are educated in appropriate business area.

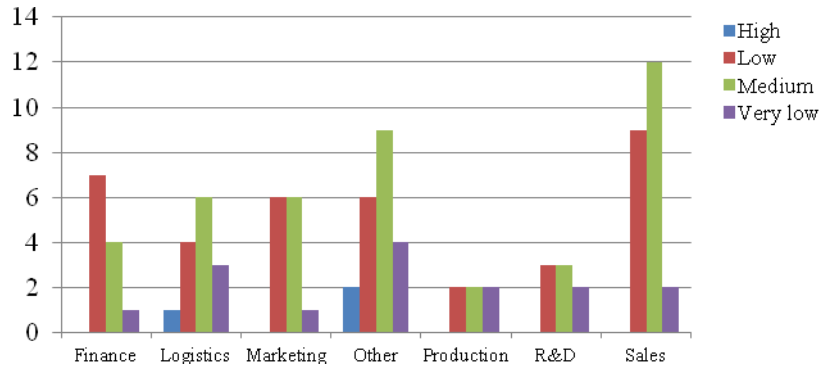

Figure no. 6: Cross-analysis of the level of spreadsheet abilities and field of application

Since, there is an alarming lack of high-level spreadsheet educated employees in every examined functional area (Figure no. 6), it is necessary to take certain steps in overcoming this issue. Appropriate spreadsheet training for those participants considers contextual education and spreadsheet management. At this level creators have to plan future usage of spreadsheet (who, when, how often, how many people will use it), resources to construct the spreadsheet model (time, people, money), anticipated future modifications, and any standards to be followed (Grossman, 2006). Advanced training includes advanced spreadsheet programming and VBA. Additionally, as company managers they have to understand importance of spreadsheet quality control, debugging approaches, and management of spreadsheet model assets. Some of guidelines for curriculum that covers quality control and debugging approaches are presented in (Jannach et al., 2014.). Management of spreadsheet model assets refers to spreadsheets in the context of valuable organizational assets. Spreadsheet models and applications shouldn't be considered just as a personal productivity tools. Spreadsheets are artefacts which have to be managed in order to insure efficiency, effectiveness and transferability. Mentioned spreadsheet issues represent part or spreadsheet engineering and management knowledge that should be incorporated in courses for higher education level. On the other hand, this knowledge corresponds to highest level of spreadsheet trainings, designed for managers and heads of departments.

Contextual spreadsheet education in logistics area, for example, covers use of key performance indicator models (Parmenter, 2015), inventory control system modelling (Antic et al., 2015), inventory simulation and optimization models (Liu et al., 2013), etc. In the context of sales and marketing, spreadsheets are useful tool for forecasting methods implementation (Gardner, 2008), budget planning, decision modelling (De Reyck and Degraeve, 2006), etc. For example, interesting approach for introducing spreadsheets in education of logistics managers is presented in (Djordjevic and Vasiljevic, 2013). Authors present approach of modelling logistic problems as discrete controlled object in spreadsheet. Some other examples include usage of spreadsheet for teaching the dynamics of lot size and variance reduction, dynamics of supply chains and business dynamics (Gardner, 2008).

Conclusion

Science and practice have achieved consensus about the importance of spreadsheets in both education and business application. Research presented in this paper also confirms this premise. What is specific about this scientific area is that it is based on the pull from the practice, that is, the practice (starting with finance and accounting fields) initiated the need for spreadsheet usage and this type of education.

There are still many school and faculties where importance and complexity of spreadsheet education levels is not recognised and incorporated in curriculum of courses. As a consequence, there is a serious disadvantage in underestimation of the challenges and corresponding educational opportunities that occur when people build sizable spreadsheets for important business problems.

Spreadsheet best practice can be revealed for different types of users, for specific business area. Further, best practice recommendations represent guidelines for improvement of university courses that include spreadsheet knowledge. In this paper, we made initial effort to have an insight in the current usage of spreadsheet tool, the main education sources, and the main fields of its application. The results show that this tool is applicable in almost

every functional area of company. Although, the main source of knowledge is formal education, its quality is not on the expected level. Consequently, it is necessary to identify further improvement directions, through the definition of curriculum content which integrates spreadsheet engineering and domain knowledge of some university courses (i.e. financial management, operations research, logistics, marketing etc.). Additionally the effects of these findings are directly depending on the readiness of university management to accept the identified curricula improvements.

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