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New Approach to Information Systems Engineering Study Program to Meet Industry Expectations*

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Information system engineering is a complex discipline which involves learning different skills, from both technical and organizational point of view. At the Faculty of Technical Sciences, Novi Sad, the initial information system engineering study program has been changed with the goal of improving knowledge quality of future engineers. The reformed information system engineering study program combines lessons and lectures, studying and usage of a world class information system, workshops and students practice in enterprises (internship). The work of the fifty newly employed engineers in five information technology companies has been assessed for the sake of exploring the benefits of the reformed study program. Half of them studied in accordance with the initial study program, while the other half studied according to the reformed one. Data have been gathered via the questionnaire consisted of eleven questions, which tested the employer's satisfaction with their work. The answers have been statistically analysed and subjected to data mining techniques in order to evaluate the improvement of the engineers' skills. Three out of eleven questions are in correlation with the reformed study program. The given answers indicate that the engineers' knowledge gained at this program is significantly better and, thus, put in better use within the company they work for.

Keywords: improvement; information system engineering; learning environment; study program

1. Introduction

Information and communication technologies have a role in every aspect of modern society and are intensively used in all spheres of life. Information systems, with application of these technologies, enable that tasks and processes in organizations are performed faster, easier and with less costs. There are different kinds of information systems available today, differing by the level of support they provide for everyday operating tasks. The widely used kinds of information systems enable planning of all resources in organizations. They are known as enterprise resource planning (ERP) systems. Organizations use the ERP systems for fast and accurate information management and automation of operative tasks [1]. ERP systems integrate all processes which happen in organizations and in general improve work efficiency [2]. Information system engineer profession experiences rapid growth. However, many newly employed engineers need additional intra-organizational training upon graduation.

Many companies demand that the students are educated not only for the application of certain technology, but also in the area of how a company works in terms of its processes. For example, a trading company can require from students to have some knowledge about sales, procurement and warehouse management. The same company can demand from them to know how these processes are presented and integrated through the application of information system. ERP systems are based on the company's processes. Changes in these processes are also reflected on the ERP system reconfiguration, in terms of changing existing or adding new functionalities [3]. For an information system engineering student, it is important to understand the methods and mechanisms which lie beneath the everyday operating tasks of the ERP systems [4].

Why is education and training on the ERP system and business processes so important?

When implementing ERP systems into organizations, there are numerous factors which influence the success of implementation process. In the research concerned with the successful implementation of the ERP system in small and medium enterprises [5], the critical success factors are divided into three groups (organizational, neutral and operational). Software training, business process re-engineering, software configuration and education on business processes are recognized as some of the critical factors [5]. Also, the research presented in [6], which is conducted in 217 organizations, shows that the success of implementation of the ERP system has several key drivers including training, education and business process re-engineering. The research concerned with the adoption of the ERP system analyses critical success factors [7]. The authors in [7] analysed 48 research publications, and they emphasized education and

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training as one of the most frequent critical success factors. Business processes knowledge is very important in order to understand the improvement in the organization's performance caused by the implementation of the ERP system. The performance of the implemented ERP system can be measured in companies by using process key performance indicators (KPIs) [8–9]. KPIs can be defined as a time necessary for process tasks execution, as a cost of workforce needed to execute a certain task, or as a percent of an error which causes the repeating of a process task or a group of tasks.

Taking the above mentioned facts into account, the successful development and implementation of the information system depends on the previous education of the engineers. The importance of preparing students for real world engineering tasks is crucial in order to enable future engineers not only to understand what is going on in the company, but how the changes happen and how they are implemented into the system.

This paper presents an example of the learning environment where engineering students can experience information system as a finished product. They deal with the case studies that simulate different tasks from organizational processes. The students gain an access to the ERP system through the SAP University Alliances program [10]. The students learn about company's processes and have an insight of how these processes are realized within the ERP system.

Improvement in learning is measured by an assessment done in the companies that employ the students upon graduation. For this purpose, the questionnaire is developed. The results from the questionnaire are subjected to statistical analysis and data mining techniques in order to confirm that the reformed study program provides engineering students with the better knowledge.

The contribution of the paper is the improvement of the engineering education through the application of combined learning environment.

This paper is structured as follows. The second section presents previously published approaches to engineering education such as laboratory work, workshops, company practice and hackathons. The third section describes the developed combined learning environment within the reformed study program. The fourth section presents study program improvement assessment. Finally, the fifth section holds the conclusions and the future work.

2. Learning environments for engineering education

Learning environments, which enable engineering students to gain practical knowledge, take several forms. An information system engineer needs to have knowledge about current technologies and their applications, and about future technologies which will change the way everyday work is carried out. Learning environment can be exemplified in the form of laboratory work, a specialized event like a workshop or a hackathon, or the organizational environment where students' practice is done.

Laboratory work prepares students for real world tasks and problems in a controlled environment [11], and it combines industry experience with experimentation [12]. There are computer equipped laboratories with their own servers and network equipment, enabling different engineering tasks, such as network development [13], virtual laboratories [14, 15], remote laboratories [16], or hybrid forms of laboratories like presented in [17, 18]. In the area of information systems laboratory work covers a wide range of processes, enabling development of skills, such as information system design, algorithm testing, programming and database development. Dependent on the form of a laboratory (physical, virtual or remote), the knowledge transfer can be enabled in several ways. In [19] the knowledge is transferred through organizing the teams of students on a software development project work, where each student takes multiple team roles. Students can gain knowledge within a virtual laboratory by participating in simulated environments with defined scenarios [20]. In remote laboratories students learn about control systems through remote access on equipment [21, 22].

Besides laboratory work, another way to empower students with practical knowledge is through the organization of workshops and hackathons. Hackathons present organized events which enable groups of students to work on the application of some technology or work on a solution of a problem. Hackathons are becoming more and more popular ways of teaching and can be combined with other means of teaching [23]. Organizational practice (internship) introduces real world tasks to student and serves as a checkpoint for students' current knowledge portfolio. Students can do assignment projects in organizations or can do their final graduation project which is a part of a bigger project currently done in the organization.

2.1 Information systems engineering studies at other universities

Information systems engineering is taught at various universities at all levels (undergraduate and postgraduate), either integrated into a study program or as a separate study program.

Learning environments at most universities, besides classrooms, include computer equipped laboratories for students' practical work [24–31].

Besides classical learning environment, there is also online learning environment [25, 26], and learning via real-time web conferencing [26].

Universities provide subjects which enable students to learn information system development technologies. These subjects cover several important areas that concern database design and development, algorithms, web and desktop programming, information security, and computer networks [24–31]. Some of the subjects are taught as compulsory courses, while the others are optional.

Many universities recognised the importance of ERP systems, and integrated them into their curriculums (their students study the function of ERP systems and the methods used for fast implementation of the ERP systems into companies) [25, 28, 31]. In addition, the ERP system simulation competitions for students can provide additional knowledge about ERP systems [32, 33].

Many universities recognise enterprise architecture and business processes knowledge as extremely important, and offer these courses as parts of the information systems curriculum [24, 27, 28, 30, 31].

Software development project involvement is also recognised as an important education factor, either through students' internship [28, 32], or through practical assignments done during studies. At some universities, students can work in teams on a project for a real customer or a client, in order to experience all the phases of software development project [27]. At other universities, students experience both team based projects and individual projects [29].

The key is to know how enterprise processes are executed and how information systems work. It is also of utmost importance to gain knowledge about development technologies and to have work experience in real-world projects. The learning environment that combines the above mentioned approaches is presented in the next section. It has been developed in order to improve engineers' knowledge.

3. Development of the learning environment for engineering education

At the Faculty of Technical Sciences (University of Novi Sad, Serbia), undergraduate information system engineering studies provide knowledge for application of information and communication technology in diverse industries. Upon graduation, information system engineers can work in different teams for design, development, testing, implementation, maintenance, integration, safety and security of information systems. Students can find employment not only in software development companies, but also in companies that have their own IT departments. Students gain the theoretical and practical knowledge in different areas, such as system engineering, organization and economics, computer and networks architecture, design and development of databases, programming, data mining, working with big data, managing the development, implementation and maintenance of information systems, and the project management of the information system development and implementation. The emphasis is on training the future engineers to perceive all the aspects of the observed real system (organization) and to be able to develop applications in various domains.

3.1 Initial study program

The initial study program for information system engineering education had a goal of educating students on development technologies. It consisted of two stages:

- Learning database development and database management systems for the development of information systems and
- Learning programming languages, data structures and algorithms for the development of information systems.

Students developed information system for a fictive organization by simulating the processes in the systems, like warehouses, stores, libraries, etc. In order to present the developed information system, students used fictive data. The initial study program was of good quality, but it lacked the sufficient input of how the real-world organizations use the information systems.

3.2 Reformed study program

The study program developed in the last few years is quite different. Since the future information system engineers need to have an insight on how real-world companies function, the learning focus is on several areas, as shown in Figure 1. Having in mind the goal of giving broader knowledge to information system engineering students (in order to help them gain more knowledge and skills which will help in the job searching process), the reformed learning model consists of several key fields:

- Learning about the organizational structure and the processes in organizations (companies from both private or public sectors), the way these processes change, what are their KPIs, which information is important for each process, and what are the functionalities of the information system (if it exists in the organization);
- Getting to know process discovery methods and

modern process modelling languages in order to understand and analyse the processes of interest;
- Informing about how these processes are implemented through the real ERP system and what information is used in such a product;
- Grasping different development technologies and the ways they can be applied (database management systems, computer networks, programming languages, data structures and algorithms);
- Organizational practice (internship) that can be conducted in a software development company or in a company which implements some sort of information system.

The organizational processes can differ from one company to another, but they all follow the same basic steps. For example, procurement process is different in two companies, but it consists of inventory inspection, supplier communication, handling procurement documentation, shipment processing, quality and quantity inspection, complaints management etc., as basic process tasks. Students have to do an obligatory assignment project that includes modelling a process from a real organization. This assumes that students first need to have an insight into the process of the organization, and to get to know all its activities, information flows, documentation, decision points and resources. After that, the process is analysed and modelled with the use of some process modelling language, such as Event-driven Process Chains (EPC), Business Process Modelling Notation (BPMN), or Unified Modelling Language (UML). Completed assignments serve as an example base later in the education process. An information system engineering student has to learn how processes work, because without understanding organizational processes, learning of the ERP system has no purpose.

Process implementation in a real world information system (ERP) is realized through SAP University Alliances program. This program is developed with the goal of educating students for the latest technologies. SAP University Alliances program means that members have access to learning material such as curricula, white papers, videos, case studies, webinars and other interactive resources. The most interesting part is that students learn how to use the ERP system through several different case study scenarios of the company which produces and sells bikes. This example company has its organizational structure, its master data and transactional data, business process workflows and business process rules. Case study scenarios cover all important processes which can happen in production planning and control, sales and distribution, procurement, warehouse operations, financial accounting, controlling, human resource

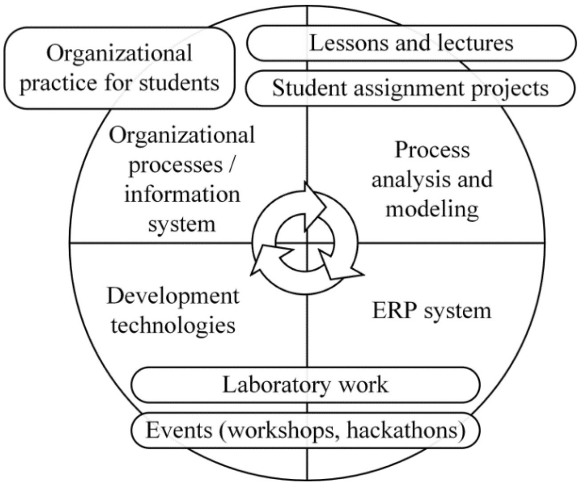

Fig. 1. Reformed learning model for the Information systems engineering program.

management, enterprise asset management, and project management.

Introducing ERP system education into the learning process is very important. The ERP system consists of several parts which are called modules. By learning the modules of the ERP system, the information system engineering students get ideas of how their own products could function and what steps they should take in order to develop one. Information systems laboratory consists of thirty-two PC computers for students, one client computer for a teacher, one server for user accounts management and user data storage. It also includes presentation and network equipment. Every workstation computer has SAP ERP GUI software installed. This client software enables students to connect to the ERP system server which is located at the University Competence Centre. Laboratory configuration is shown in Figure 2.

Laboratory work consists of three parts: introduction to the module, the exercises and the case study. Introduction to the ERP module is made by a professor via presentation. It consists of the organizational structure description, process explanation, data and documents explanation, and the process outcomes.

The second part is the exercise which covers basic functionalities of the ERP module students get familiar with. Students do the exercises using learning materials and with professor's guidance.

The third part is the case study supported by the learning material which describes the learning objective, scenario and process description that leads students through the whole process. Students work through their case study tasks independently, with the minimum help of the professor. Each student's account has a copy of the company's data to avoid data inconsistency. Time to complete

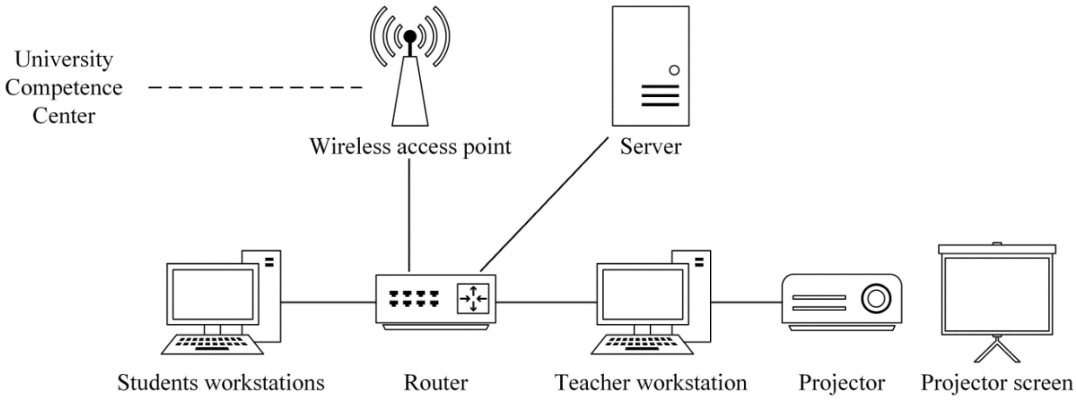

Fig. 2. Information system engineering lab configuration.

all the tasks differs from one module to another. This is the part where students learn the most. Students' knowledge is tested by giving them challenge solving tasks after the case study is completed. Case study scenarios overview is shown in Table 1.

Besides laboratory case studies, students also can attend different events which cover the application of the technologies they have learned and work there in teams. These events usually last for one or two days and they can take a form of a workshop or a hackathon (usually organized in the laboratory for 30 students). These events are led by an experienced instructor or an engineer from the software development company.

Comparison of the initial and reformed curriculum is presented in Table 2.

Table 1. ERP system modules and case studies

ERP module	Number of case studies	Case study scenario(s)	Projected working time [minutes]
Sales and distribution	1	Order-to-cash process	120
Materials management	1	Purchasing process	140
Production planning and Execution	1	Manufacturing process	140
Warehouse management	4	Receiving goods process Transferring goods to plants Issuing goods for a sales order Conducting physical inventory	70 90 70 60
Financial accounting	1	Complete accounts payables process	65
Controlling	2	Cost center accounting Product costing process	105 55
Human capital management	2	Recruitment process Payroll process	140 45
Project system	1	Project planning process	140
Enterprise asset management	1	Maintenance process	60

Table 2. Comparison of the initial and reformed Information Systems Engineering curriculum

Curriculum	Initial	Reformed
Areas covered		
Database development	Yes	Yes
Database management systems	Yes	Yes
Programming languages	Yes	Yes
Data structures and algorithms	Yes	Yes
ERP systems	No	Yes
Organizational structure and the processes in organizations	No	Yes
Process discovery methods and process modelling languages	No	Yes
Organizational practice	No	Yes
Participation in hackathons	No	Yes

The next section presents the study program improvement assessment, evaluation process of newly employed engineers, and discussion of the resulting dataset analysis.

4. Study program improvement assessment

The presented research consists of the evaluation taken in five IT development companies, from Novi Sad, Serbia. The number of evaluated persons is 50. All of them are graduated bachelor students employed in these companies immediately upon graduation for at least twelve months. The engineers are chosen for the evaluation based on their faculty data for their study program (initial or reformed). They are previously contacted and informed about the research goals and purpose. Half of the evaluated engineers attended the studies according to the initial program and the other half in accordance with the reformed program. The scope of work of these companies ranges from software engineering to information systems design and provision of other services in the area of information technologies. All five companies provided internal training so that the beginner engineers could be included into work process as soon as possible.

Responsible persons (evaluators) from the companies received a questionnaire used for evaluating the newly employed engineers. During the evaluation process, the evaluators did not know the type of the study program the engineers attended. This information was presented to the evaluators after the evaluation process ended. The questionnaire consisted of the questions presented in Table 3. Except for question 1, all the other questions offered the answer scale from 1 to 5, where grade 1 means "very dissatisfied", 2 means "somewhat dissatisfied", 3 means "neither dissatisfied neither satisfied", 4 means "somewhat satisfied" and 5 means "very satisfied".

The answers' dataset consisted of the evaluators answers for every engineer. The data in the answers dataset comprise of several columns:

- the first column represents the engineer's label (S1–S50),
- the second column represents the company's label (C1–C5),
- the next eleven columns represent the answers to the questions Q1–Q11 ranging from 1 to 5 (except column Q1),
- the last column, which is labelled "Prog", represents the study program the engineer attended (N- reformed, O- initial).

The resulting dataset is statistically analysed in order to confirm the statistical difference between the two groups of engineers (the engineers who studied according to the initial program and the engineers who studied in accordance with the reformed program). The statistical analysis also shows which questions from the questionnaire are the best predictors of the study program. Additionally, the data mining techniques are applied in order to find useful insights about study programs. Those data mining techniques are a part of the state-of-the-art computational process of discovering patterns in large data sets. They involve methods at the intersection of artificial intelligence, machine learning, statistics, and database systems. Data mining is

Table 3. The questionnaire for the work evaluation of the newly employed engineers

Question label	Question	Answer scale
Q1	How many months is the engineer employed in the company?	Number of months $\geq$12
Q2	How are you satisfied with the knowledge quality of the engineer when he/she entered the company?	(1–5)
Q3	How did the engineer fit into the team?	(1–5)
Q4	How are you satisfied with the practical work of the engineer?	(1–5)
Q5	How are you satisfied with engineer results on internal training?	(1–5)
Q6	How are you satisfied with the time that the engineer needed to achieve the level of providing the useful work?	(1–5)
Q7	How does the engineer manage in the emerging situations?	(1–5)
Q8	How are you satisfied with the willingness of the engineer for learning of new technologies?	(1–5)
Q9	How do you grade engineer's job satisfaction?	(1–5)
Q10	How are you satisfied with the current work performance of the engineer?	(1–5)
Q11	Evaluate the engineer's perspective in this job.	(1–5)

chosen as additional methodology for the presented work, and it is more than just statistics. It covers the entire process of data analysis, including data cleaning, preparation and visualization of the results, and how to produce predictions in real-time.

4.1 Statistical analysis

Exactly 50% of new engineers finished their studies according to the reformed program and the other half according to the initial program. The distribution of new engineers in the companies is approximately equal (approx. 20% of engineers is from one of five companies). The time analysis shows that 46% of the engineers have been working between 12 and 18 months in the company, 22% have been working between 19 and 24 months, 20% have been working between 25 and 30 months, and 12% have been working between 31 and 36 months.

The IBM-SPSS software is used to test differences between groups. In case of ANOVA tests at significance level $\alpha = 0.05$, the lowest p-value is 0.000 (on the questions Q4, Q5, Q6, Q7, Q8, Q10, Q11) and the highest is 0.063 (Q3). There is a statistically significant difference between groups as determined by one-way ANOVA ($F(1,48) = 129.906$, $p = 0.000$). Therefore, it can be said that the skills engineers gained while studying at the reformed program significantly differ from the those gained at the initial program.

Based on the Linear Regression results, questions from Q2–Q11 predict whether the engineer studied according to the reformed or the initial study program, with coefficient of determination (R-square = 0.850, p-value = 0.000), as shown in Table 4.

B-values with p-values are presented in Table 5. Questions Q6, Q7 and Q8 are the best predictors of the study program.

Table 4. Analysis of variance—complete dataset

ANOVA[a]						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	10.622	10	1.062	22.053	0.000[b]
	Residual	1.878	39	0.048		
	Total	12.500	49			

a. Dependent Variable: Prog.
b. Predictors: (Constant), Q11, Q3, Q4, Q9, Q5, Q2, Q6, Q7, Q8, Q10.

Table 5. Correlation coefficient and p-values—complete dataset

Coefficients[a]						
		Unstandardized Coefficients		**Standardized Coefficients**		
Model		**B**	**Std. Error**	**Beta**	**t**	**Sig.**
1	(Constant)	3.745	0.317		11.798	0.000
	Q2	0.113	0.074	0.158	1.532	0.134
	Q3	–0.037	0.040	–0.062	–0.937	0.355
	Q4	–0.040	0.052	–0.058	–0.770	0.446
	Q5	–0.047	0.048	–0.076	–0.980	0.333
	Q6	–0.197	0.056	–0.325	–3.538	0.001
	Q7	–0.193	0.058	–0.358	–3.320	0.002
	Q8	–0.207	0.091	–0.324	–2.284	0.028
	Q9	0.069	0.067	0.078	1.030	0.309
	Q10	–0.017	0.147	–0.023	–0.116	0.909
	Q11	–0.045	0.098	–0.070	–0.455	0.652

a. Dependent Variable: Prog.

Table 6. Analysis of variance—Q6, Q7, Q8

ANOVA[a]						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	10.242	3	3.414	69.569	0.000[b]
	Residual	2.258	46	0.049		
	Total	12.500	49			

a. Dependent Variable: Prog.
b. Predictors: (Constant), Q6, Q7, Q8.

Table 7. Correlation coefficient and p-values—Q6, Q7, Q8

Coefficients[a]						
		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	3.809	0.168		22.606	0.000
	Q6	–0.185	0.054	–0.305	–3.426	0.001
	Q7	–0.233	0.048	–0.433	–4.860	0.000
	Q8	–0.197	0.052	–0.308	–3.767	0.000

a. Dependent Variable: Prog.

In the second iteration, the Linear regression is conducted only with the questions Q6, Q7 and Q8 (R-square = 0.819, p-value = 0.000). Detailed results are shown in Table 6 and Table 7. In comparison with the previous analysis, coefficient of determination R-square slightly decreased in value with the same significance (p-value = 0.000).

4.2 Data mining analysis

The answers dataset is also analysed with data mining techniques in order to find correlation between the answers to the questions and the study program the engineers attended during studies. The goal was also to find which attributes characterize the evaluated engineers. The chosen data mining method is classification, according to which the engineers can be classified into O or into N class, based on the given data from the answers dataset. For that purpose, several most widely used machine learning algorithms were evaluated.

Naïve Bayes algorithm implements the probabilistic Naïve Bayes classifier [34] and it is widely used in data mining experiments. A Naïve Bayes classifier considers all the features that contribute independently to the probability that an instance is a member of a certain class, whether or not they are in fact related to each other or to the existence of the other features. KStar is the so-called ''lazy learner'', since it stores the training instances and does not perform real work until classification time. It is a nearest-neighbour method with a generalized distance function based on transformations proposed by Aha, Kibler and Albert [35] and also by Cleary and Trigg [36]. J48 is an implementation Quinlan's C4.5 decision tree learner [37]. C4.5 builds decision trees from a set of training data, using the concept of information entropy. Alternating Decision Trees (ADTree) [38] is a machine learning method for classification, which generalizes decision trees and is associated to boosting. Boosting algorithms typically use either decision stumps or decision trees as weak hypotheses.

Metrics used for the evaluation of classification power of the algorithm were ''Accuracy'' and ''Area under the ROC curve''. The ''Com'' parameter was not used in the evaluation in order to generalize the results for all companies. The parameter ''Q1'' was not used because it almost unambiguously defines the class of the problem—for engineers who work longer in the company there is a higher chance that they studied according to the initial program and vice versa, for the engineers who work for a shorter period in the company. Evaluation is done on the parameters Q2–Q11, and the research class was the ''Prog'' parameter. The 10-fold cross validation method is used to test the resulting models for the purpose of verifying the classification. The results of the evaluation of five most widely used machine learning algorithms from different groups are presented in Table 8.

Table 8 shows that the best result is achieved with the use of ''ADTree Decision Tree'' algorithm, as in many other researches done so far [39–40]. Based on the answers given to the questions Q2–Q11, the developed model determines whether the engineer studied according to the initial or reformed program, with 98% accuracy and with RPC parameter equal to 1. This proves that the answers to the questions given by the evaluators absolutely correlated with the study program the engineer attended. The resulting tree is shown in Figure 3.

Afterwards, the analysis of the resulting model (based on ADTree Decision Tree) is done, aiming at discovering which of the questions influenced the prediction results most. The new model is obtained after adjusting the parameters. More specifically speaking, by reducing the number of boosting iterations from 10 to 4. This new model makes predictions based only on three questions, with 98% accuracy and with a slightly lesser ROC

Table 8. Data mining techniques—achieved results

	Machine learning algorithm	Accuracy	ROC
1.	Naïve Bayes	94%	0.995
2.	Lazy KStar	94%	0.998
3.	Decision tables	92%	0.946
4.	J48 Decision Tree	88%	0.929
5.	ADTree Decision Tree	98%	1.000

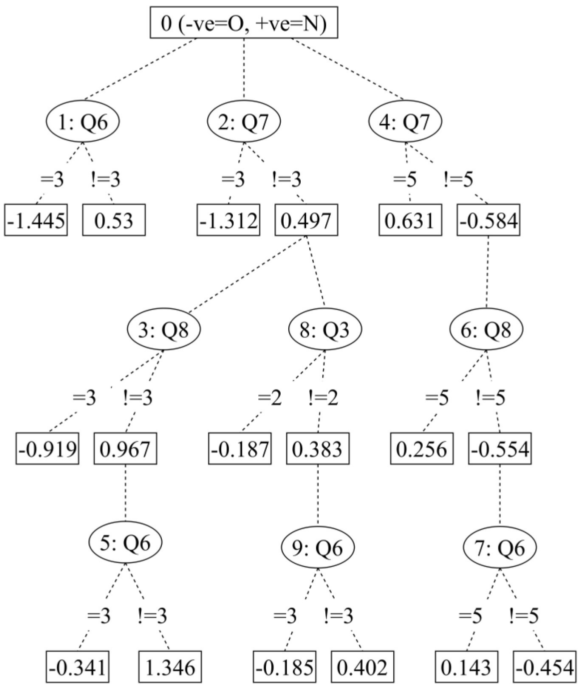

Fig. 3. ADTree Decision Tree results.

parameter of 0.989. The resulting tree is shown in Figure 4.

ROC curve of the resulting model is shown in Figure 5.

4.3 Discussion

Figure 4 shows that the most influential questions are Q6, Q7 and Q8. Engineers who studied according to the reformed study program managed to complete certain tasks more efficiently. The evaluators are most satisfied with the results these engineers have achieved. Engineers who studied in accordance with the reformed program can manage very well in challenging situations and are also more willing to learn new technologies. These

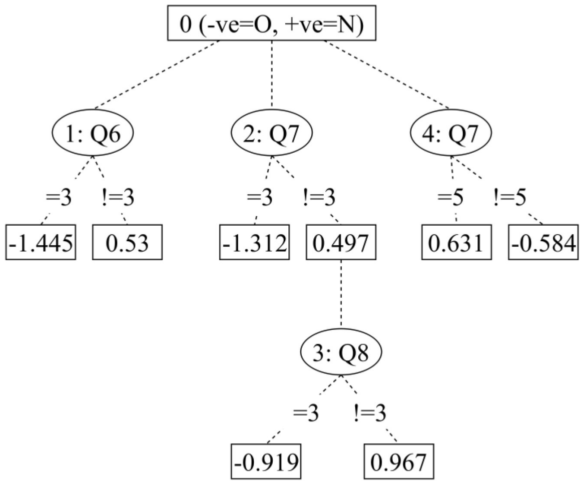

Fig. 4. ADTree Decision Tree results based on only 3 parameters.

three questions are in the largest correlation with the type of study program class variable. This means that the engineers could be classified according to their study program just by giving answers to the questions. This implies that this characteristic actually represents the quality of the study program.

Limitations of the conducted assessment lies in the fact that only the work of former students employed in IT companies is observed. There are also other types of companies that do not have IT development as a primary process, but have the IT department which carries out the IT related tasks (for example there could be the IT department in a factory for production of automobile parts, in an oil production refinery, in a bank, in an insurance company etc.). This means that the engineers employed in these types of companies could have other types of daily tasks, which could be different than the tasks performed in IT development companies (for example extracting, transforming and loading of data, integrating data from different types of data sources for the purpose of data

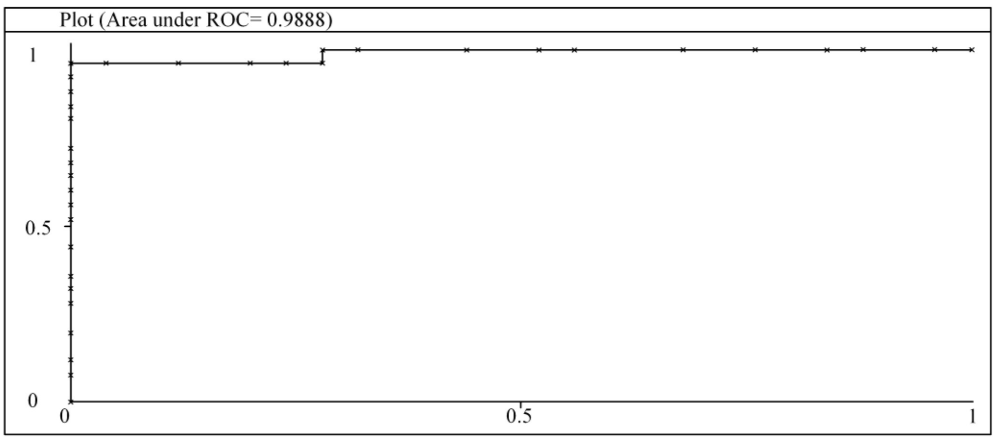

Fig. 5. Area under the ROC curve—ADTree Decision Tree based model.

analysis etc.) Taking all the above mentioned into consideration, it can be concluded that the reformed study program help students achieve better results once they start working upon graduation.

5. Conclusions and further research

This paper presents the reforms in the study program through the development of the learning environment that combines several learning approaches: theoretical knowledge with technical, organizational and process background, laboratory work, organizational practices and trainings, and events, such as thematic lectures with practical work. The questionnaire has been used in order to determine the level of improvement of the study program. It was distributed to five IT companies that employ the newly graduated engineers who all studied Information system engineering, either the initial or the reformed program. The given answers were analysed statistically and with data mining techniques. The results show that the engineers who studied according to the reformed study program produce real value to the company in a shorter time span. Moreover, they are more willing to learn new technologies and are able to deal with more changeling work conditions, when compared to those who studied in accordance with the initial study program.

The developed approach is also partly applied to the other study programs as well, such as industrial engineering and engineering management study programs. By doing the ERP system case studies the students from these study programs gain valuable knowledge about information system application areas and functionality. Companies which use ERP systems could have lesser investment into additional education of newly employed engineers if they already have some knowledge obtained during studies. Plans for the near future are concerned with further improvements of the learning environment on a more personalized basis. This includes tracking students' progress over time and providing them with learning choices based on their preferences and interests (using modern technology, such as smartphones, for learning).

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