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Learning Challenges and Performance in the Databases Course

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Abstract: *The Databases is a core course in computing disciplines since almost all systems require data storage component. Teaching a database course, in general, is a challenging task, due to several factors, such as increasing expectations of the job market, limited time frames of a regular semester system, to name a few. Nowadays, many organizations are turning to NoSQL databases as their preferred system of capturing and storing massive amounts of data, which is actually one of the many challenges and possible improvements in teaching. Therefore, it is likely that employees in all sizes of organizations will encounter NoSQL databases. At the Faculty of Technical Sciences in Čačak, relational databases are studied in the second year of studies, and the students enrolling in these studies have different prior knowledge in this field. This study examines the possibilities of teaching improvements to the Database course, such as the introduction of NoSQL databases, problem-based learning, solving practical problems, designing, gamification, etc., so that future database designers acquire the advanced level of knowledge required at the market. A survey of second-year students was conducted to determine their views and attitudes towards the Database course improvements.*

Keywords: *database; education; SQL tools; NoSQL*

1. INTRODUCTION

Over the last decade, databases have become a very important factor that has an impact on humans' lives, in almost all spheres of life. The traditional Database course teaches students about concepts and skills, such as entities, relationships, normalization, and data structuring, that are geared around relational databases. Standard Query Language is typically used to create tables and store data in databases. Students need to query data in order to build knowledge from them.

However, increasing demands of big data force companies to turn to NoSQL databases, as their preferred system, i.e. as one of the challenges and possible improvements in the sphere of business and education [1]. No-SQL, which is an acronym for Not Only SQL, databases refer to high-performance, non-relational data stores. Instead of joining tables of normalized data, NoSQL stores unstructured or semi-structured data [2]. Hence, it is almost inevitable for employees in organizations to encounter NoSQL databases. In order to meet the requirements of the market, students need to be introduced to this technology.

Our analysis related to the Databases course involves students enrolled in the second year at the University of Kragujevac, Faculty of Technical Sciences in Čačak. A survey was applied to the Databases course and the participation was optional and anonymous, in order to increase the freedom of the students responses.

In the first part of the semester, students learn about database fundamentals. The second part of semester is devoted to SQL and is applications. A survey was applied at the end of the semester, after the examination period, to all the 130 students that were enrolled in the course.

The goal was to analyze their perceptions related to the Databases course, their knowledge level, and attitude towards new materials and learning challenges, such as the introduction of NoSQL databases, solving practical problems in accordance with social needs, problem-based learning, designing, gamification, i.e. the integration of game elements into non-gaming environments in order to increase the engagement, motivation and performance of students in education, etc., which other authors have encountered in related work.

The rest of this paper is structured as follows: Section 'Related work' goes through different approaches faced by other professors, and proposes solutions to increase the efficiency, first of all of the database course, but also of other courses. Section 3 describes survey design and methodology used in the research. Section 4 discusses results obtained in the survey. Finally, in

Section 5, a conclusion and the future work are presented.

2. RELATED WORK

The application of the concept of education based on outcomes, as the main strategy for teaching reform was presented in the paper [3]. A series of reform measures and solutions from the aspects of formulating teaching goals, optimizing teaching content, innovation of teaching methods, optimization of experiment design, system innovation, evaluation, etc. was described. Outcome-based education is a type of educational mode that focuses on nurturing students' ability to solve practical problems according to social needs. Therefore, all aspects of this educational method are designed and implemented close to the students.

Through research [4], the authors argue that problem-based learning (PBL) provides a powerful framework for introducing database concepts to a wide range of students. Designing, i.e., database modeling, presents complex problems with multiple possible solutions. Database problems are necessarily interdisciplinary and involve both problem domain and technical expertise, supporting some real goals. Therefore, common problems in the database domain align with PBL definitions of good problems.

In [5], the authors deal with the term "Gamification", namely the integration of game elements into non-gaming environments, in order to increase student engagement, motivation, and performance in education on the computer science and software engineering study program. Namely, this view prompted the authors to create "QueryCompetition", a web system, that allows students to practice SQL in a competitive environment with the aim of obtaining empirical evidence on how elements of "Gamification", such as challenges, points, and leaderboards, integrated into this environment, affect student performance, motivation, and user experience. They conducted an experimental study with two groups of students in the Database course. One group used a gamified version of this system with access to points and leaderboards, while the other used a non-gamified version without access to the above elements. Quantitative and qualitative data were collected through tests and a survey. The results showed that there was a statistically significant improvement in student performance in the gamified group compared to the non-gamified group. In addition, higher motivation was observed in the gamified group. The results presented in this paper support the claim that the inclusion of challenges, points, and leaderboards, together with the competitive nature of the "QueryCompetition", positively affects student performance and motivation to practice SQL in their education and further career progression.

Through the conducted research [6] the authors came to the conclusion that dealing with psychological problems is essential for improving motivation, goodwill, and increasing skills and abilities, which can be correlated with students and their performance through education and their motivation. According to the authors of this paper, people belonging to all professions experience psychological problems in their personal and professional lives. The measures that should be implemented in providing solutions to psychological problems are: forming an effective social circle, working in a team, alleviating loneliness, strengthening cordiality and kindness in relationships, good information about work duties and responsibilities, good equipment in terms of methodologies and procedures, strengthening a constructive approach, receiving counseling and guidance, and creating a pleasant business and educational environment, which further leads to the improvement of personality traits and enrichment of living standards. The benefits of providing solutions to psychological problems lead to increased levels of motivation and concentration, improving one's career prospects, and increasing skills and abilities.

In his work [7], the author examines the process of transferring knowledge on the database in the higher education system, the current state, the form of organization of training, methods used, tools, organizational work, and their problems and shortcomings, and analyzes ways to overcome them. Through survey, students noted the problems in the database courses, such as more theory than practice, the old pedagogical technologies, limited database training, etc. The author suggests practice-oriented learning technologies in the classroom in order to overcome the mentioned problems.

The study presented in [8] explores and analyzes the learning tendencies of students enrolled in different lines of study related to the Databases course. Through a survey authors concluded that students prefer learning only the basic information that could help them achieve their goals: creating an application or using it at work. Authors in [9] conducted a systematic literature review by selecting research papers published between 1995 and 2021. They have also discussed how the developed teaching and learning assistant tools, methods, and database curricula have evolved over the years due to rapid change in database technology. The article also provides useful guidelines to the instructors, and discusses ideas to extend this research from several perspectives.

The authors in [1] propose the inclusion of essential knowledge about NoSQL in a traditional relational databases course. A NoSQL unit with an Excel-

based NoSQL database example has been designed and introduced to business students. The authors state that the design and delivery of the NoSQL unit demonstrated that knowledge about NoSQL is practicable and very useful for business students. Teachers who wish to incorporate a small unit of NoSQL in their traditional database course for all business students can find this paper very useful, according to the authors.

3. SURVEY DESIGN AND METHODOLOGY

A questionnaire has been developed to propose online to students of the second year of academic studies at the Faculty of Technical Sciences in Čačak, University of Kragujevac. The questionnaire consisted of eight questions. The first three questions were related to higher school, the subject and the software tool used for databases, if any. The fourth question considered grade that was obtained after listening to the Database course. The next question was divided into eleven sub-questions that were related to the knowledge level of specified areas that were covered in the Database course. The students were asked to evaluate them using the one-to-five Likert type scale. In the next question, students have to choose one of the four statements that best describe their current readiness to work with databases. In addition, there was one open question to collect the students' opinion about the course in general. Questionnaire is given in Table 1.

Table 1. *Questionnaire: Improvement of teaching in the Databases course*

1. Choose your high school.	Grammar school
	Economic school
	Technical school
	Machine and transport school
	Catering school
	Other
2. Did you learn about databases in your high school?	
3. Which database tools you used in high school?	I didn't use any database tool
	MySQL
	Access
	phpMyadmin
	PostgreSQL
	APEX
	Some other tool
4. The grade I received in the course Databases is:	
5. On a scale from 1 (very poor) to 5 (very good), evaluate your KNOWLEDGE LEVEL for the specified areas that were worked on in the course Database.	
Modeling: Databases concepts	1 2 3 4 5
Modeling: Resolving M:M relationships	1 2 3 4 5
Relational model	1 2 3 4 5
Relational algebra	1 2 3 4 5
Normalization: I, II and III Normal Form	1 2 3 4 5
Entity-Relationship model to Relational model	1 2 3 4 5
SQL: Introduction	1 2 3 4 5
SQL: One table query	1 2 3 4 5
SQL: JOIN	1 2 3 4 5
SQL: Functions	1 2 3 4 5
SQL: Subqueries	1 2 3 4 5
6. Based on your previous experience in the Databases course, choose the statement that best describes your current readiness to work with databases.	I'm not sure I can design a database (even for a very simple example)
	I can design a simple database by myself, but it takes me a lot of time to do it.
	I can design databases for systems of medium difficulty, with someone's help
	I can independently design databases for complex systems
7. Do you think it is necessary to improve the Database course with the new areas such as NoSQL databases (currently in demand on the market)?	Yes
	No
	I don't know
8. If you have a suggestion on how to improve the Database course, you can write it in the field below.	

4. RESULT ANALSYS AND DISCUSSION

The questionnaire was administered online using JotForm[1] software. A total number of 93 students filled out the questionnaire. The data was electronically downloaded into the table, which eliminated the need for manual entry. The aims of the questionnaire were to find out if there is a relationship between students' prior knowledge in databases and their current knowledge level and to find out what the students' opinion is about the improvement of the Database course with the new areas, such as NoSQL databases. The "IBM SPSS Statistic 21" statistical package (evaluation version) was used for data analysis. Cronbach's reliability coefficient is ($\alpha = 0.745$), which indicates an acceptable level of reliability of the used questionnaire. The contribution of individual statements was determined by analyzing the arithmetic mean, standard deviation, corrected total correlation coefficients, and Cronbach's alphas after deleting each of the questions at the level of the entire questionnaire.

After analyzing the obtained results, several conclusions can be drown.

Concerning prior education, the majority of students came from Technical school (60.2%) and Grammar school (20.4%). Over half of students (54.8%) worked with some database tool in high school. Out of the total number of respondents, 83.9% passed the exam, 9.7% failed the test, and 6.5% still didn't take the exam (Table 2). It should be noted that there are 130 students enrolled in the second year, and that 37 students didn't fill out the

[1] www.jotform.com

questionnaire, so the high percent of passing the exam is somewhat lower.

Table 2. *The grade I received in the Database course is:*

		Frequency	Percent
Valid	I didn't take the exam	6	6.5
	I didn't pass the exam	9	9.7
	6	12	12.9
	7	11	11.8
	8	23	24.7
	9	14	15.1
	10	18	19.4
	Total	93	100.0

One may conclude that students that have prior knowledge on databases should score better than those who listen about databases for the first time. However, application of the Pearson Chi-Square test (p=-0.282) shows a negative correlation between the variable "Did you learn about databases in your high school?" and "The grade I received in the course Databases is:". This could be explained by the fact that students who had databases in high school pay less attention to lessons because they think they already know material. Unlike them, students who learned about databases for the first time pay more attention during the class and make more efforts in order to master material more easily.

Table 3 summarizes results obtained from question 5. Analyses revealed that students, in their opinion, gained the highest level of knowledge in the areas *SQL: Introduction* (54.8%) *and SQL: One table query* (58.1%). On the other hand, they rated *Normalization* and *SQL subqueries* with the lowest marks concerning knowledge level, 11.8% and 10.8%, respectively.

Table 3. *KNOWLEDGE LEVEL for the specified areas (%)*

Subject area	Poor	Average	Good	Very good
Modeling: Databases concepts	2.2	19.4	36.6	41.9
Modeling: Resolving M:M relationships	1.1	24.7	30.1	44.1
Relational model	6.5	21.5	34.4	37.6
Relational algebra	4.3	21.5	40.9	33.3
Normalization: I, II, III NF	11.8	24.7	20.4	43.0
Entity-Relationship model to Relational model	4.3	21.5	31.2	43.0
SQL: Introduction	2.2	11.8	31.2	54.8
SQL: One table queries	2.2	9.7	30.1	58.1
SQL: JOIN	3.2	17.2	36.6	43.0
SQL: Functions	6.5	20.4	35.5	37.6
SQL: Subqueries	10.8	19.4	32.3	37.6

The first is due to its abstraction nature, because normal forms are learned on the entity-relationship models, not on tables themselves. As for the SQL subqueries area, it is the last lesson taught at the end of the semester when the number of students is significantly reduced. When taking the exam, for most students, creating a subquery is the most difficult task.

In the continuation of the analysis, the methods of descriptive statistics (more precisely, frequency table) are applied. Out of the total number of respondents, 59.1% think that they can design a database for a system of medium difficulty, with someone's help. However, there are still students (6.6%) who are not sure if they can design databases, even if it is for the very simple system.

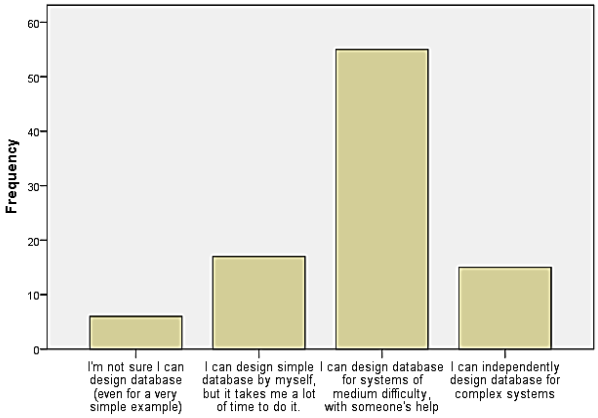

Figure 1. *Based on your previous experience in the Databases course, choose the statement that best describes your current readiness to work with databases.*

Finally, according to the analysis, the majority of students (66.7%) agree that the Database course should be improved in order to meet the needs of market demands, while 17.2% of students disagree. The rest of them (16.1%) are not sure about improvement. Tabe 4 shows distribution of answers for the improvement and the previous knowledge about databases. Pearson Chi-Square was p=0.205, which indicates dependents of two variables, i.e. students who had databases in high school seek to upgrade their knowledge. However, which is maybe more important, 57% of students who didn't learn about databases show a positive attitude about course improvement with new areas such as NoSQL databases.

Table 4. *Crosstabulation of variables: Did you learn about databases in your high school? * Do you think it is necessary to improve the Database course with the new areas, such as NoSQL databases (currently in demand on the market)?*

		Do you think it is necessary to improve the Database course with the new areas such as NoSQL databases (currently in demand on the market)?			Total
		Yes	No	I don't know	
Did you learn about databases in your high school?	Yes	38	7	6	51
	No	24	9	9	42
Total		62	16	15	93

5. CONCLUSION

Improving the quality of the educational process is one of the most important tasks. The need for research in the area of databases arose due to the growing demand for improving the knowledge of students, in order to meet the demands of the market. Since many companies use it to collect big data, NoSQL is quickly becoming an integral part of modern information systems [2].

Analysis of the results from the conducted survey shows that prior knowledge in databases has a partial influence on current students' knowledge level enrolled in the Database course. Analysis also reveals students' willingness to upgrade their knowledge level with new areas such as NoSQL databases.

Future work will focus on improving areas that students mark as the most difficult ones. Also, once the students learn how to query traditional databases, they will be introduced to a NoSQL database management system.

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