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Teaching of Database Programming for Mechanical Engineering Students

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Abstract

The evaluation of the Database Programming subject held for the first time based on educational experiences and a survey made among students. We outline the syllabus and the similar courses held on the other inland universities. With the help of data mining methods we examine the efficiency of the use of Moodle tests which play an important role in the education process. We delineate the topics that proved to be the most difficult one during the course by analyzing the test questions item by item. Finally we describe the result of the questionnaire survey.

1. Introduction

The Database Programming course was held for the first time in the school year of 2008/2009 as an optional, so-called C subject. Although we recommended it mostly for the students of Faculty of Mechanical Engineering, students of other faculties had also the possibility to attend. Finally the course was attended by eleven mechanical engineer students and one environment engineer student. Eleven of them were the member of full-time course and one was the member of correspondence course.

To attend the subject there were no requirement the preliminary participation of any other subjects. The reason of it is that the education of the informatics happens in two half-years on Faculty of Mechanical Engineering. In the first half-year students get acquainted with the interactive use of Access while in the second half-year they study programming with Visual Basic programming language. Therefore the students surely have fundamental database management and programming knowledge. In the 5th half-year the engineer informatics specialist mechanical engineer students may study the Database Management subject. These students have deeper database management knowledge. From them only one student attended the Database Programming subject.

2. Syllabus and educational circumstances

The goal of the course is to introduce those data management techniques which allow of processing the data of the databases from SQL or other high-level program language procedures. According to it the curriculum is summarized in Table 1.

The class took place in a computer lab. In the Moodle course management system different materials in PDF format and 135 test questions were available for learning. From among the test questions there were 25 procedures written on different program languages, at which the task was the understanding of the procedures and to decide about the correctness of the solution.

From the database systems we used MS SQL Server Express, MySQL and Access systems but students had access also to the Oracle Express server where they may get familiar with the PL/SQL language by themselves.

We were not able to review all parts of the topics of the syllabus. One of its reasons was that although the half part of the students already met with the SQL language before the course the depth of their knowledge was sufficient. Therefore it was necessary to devote more time to the SQL language than planned. On the other hand 75% of the students already before their university studies while 100% of the students during course of the university studies already learned programming, however only the half of the students considered so their level of programming knowledge appropriate. This have resulted a slower workflow at the phase of writing programs than planned. And last the computers of the lab are old, slow and do not have sufficient memories. We also had problems with the access of the servers sometimes which are hardware problems that contributed to the slowing down of work.

Week	**Curriculum**
1.	Relational model. SQL language. [11]
2.	SQL language.
3.	The procedural statements of the SQL language. Stored procedures. [11]
4.	Cursor handling. Triggers. [11]
5.	The basics of Visual Basic language. [16] [17]
6.	The ADO object model. [11]
7.	1^{st} written exam. Object-oriented programming. [12]
8.	Access programming. Events. [12]
9.	Access programming. Access objects. [12]
10.	The basics of PHP language. The MySQL functions of PHP. [19]
11.	The ODBC functions of PHP. [19]
12.	The basics of C# language. The ADO.NET object model. [18]
13.	Database management in Java environment (JDBC). [10]
14.	2^{nd} written exam, deadline of home works

Table 1: The syllabus of the subject

We did not deal with C# program language and with database management in Java environment. We introduced the ADO.NET object model but did not write a program onto its use. These topics of course were not part of the final written exam

3. Teaching database programming in the other inland higher educational institutions

In Table 2 the topics of database programming which are taught in other Hungarian higher educational institutions is summarized. Our source was the subject syllabi which can be found on the Internet.

Institution	**Subject**	**Topic, DBMS**
Budapest University of Technology and Economics	Server side programming of the databases [7]	PL/SQL, T-SQL, Oracle, SQL Server
Óbuda University	Database programming [6]	PL/SQL, T-SQL, Delphi, Oracle, Interbase, SQL Server
University of Debrecen	Data handling [9]	Java, MySQL, PostgreSQL
College of Dunaújváros	Database management, Web programming [2]	Programming in SQL, PHP, Oracle, MySQL, DB2
Eötvös Lóránd University	Web database programming [20], Databases in the school [5]	PL/SQL, MySQL, Oracle, MS SQL Server
Eszterházy Károly College	Advanced DBMS knowledge [14]	PL/SQL, PHP, C#, Oracle, MySQL
Kecskemét College	Databases II. [4]	Programming in SQL
University of Miskolc	Database systems II. [8]	PL/SQL, T-SQL, Oracle, SQL Server
Széchenyi István University	Database management [1]	T-SQL, VB.NET, SQL Server
University of Szeged	Databases [3]	Embedded SQL, PHP, MySQL

Table 2: Subjects and topics taught in other institutions

4. The general assessment of Moodle tests

The acquisition of the knowledge was supported by educational substances in PDF format and practicing tests placed in the Moodle course management framework system. Among the educational substances both review of the object models, the programming language descriptions and elaborated sample programs can be found. For the practicing tests we did not define a time constraint and we did not restrict the number of attempts, except the practice test for the first examination. Students solved the practising tests altogether 177 times. We summarized the tests and their features in Table 3.

Test	**Number of questions**	**Maximum point**	**Time limit (min.)**	**Number of trials**	**Average point**	**Average time (min.)**	**Result**
Access objects (ACOBJ)	11	11	0	no limit	8.9	5.4	81.7%

Access programming, events (ACPROG)	22	22	0	no limit	15.7	8.4	74.9%
ADO (ADO)	20	20	0	no limit	10.2	5.5	58.8%
ADO examples (ADOEXAMPL)	15	15	0	no limit	12.5	29.9	80.3%
PHP functions handling MySQL databases (PHP)	8	8	0	no limit	5.5	4.1	73.2%
Relational model (REL)	8	8	0	no limit	5.5	2.4	71.6%
SQL (SQL)	16	16	0	no limit	9.7	9.3	63.9%
Stored procedures (STP)	22	22	0	no limit	11.4	8.8	60.5%
Stored procedures examples (STPEXAMPL)	9	9	0	no limit	5.6	9.6	69.0%
ZH1 (test for the first examination)	21	42	45	1	37.4	14.2	89.0%
ZH1_practice (practice test for the first examination)	21	42	45	3	34.0	10.4	81.0%
ZH2 (test for the second examination)	15	30	30	1	27.9	7.7	93.1%

Table 4: The characteristics of Moodle tests and results

We displayed the results of the practising tests on Figure 1 graphically. On the figure we displayed whether the students considered the certain topics difficult too. There is no strong connection between their judgement of difficultness and the result. We calculated the correlation, altogether it is 0.364.

The average number of the trials was 14.8 per student. Most attempts happened with the relational model, Access objects, SQL and PHP functions tests. This result is very interesting considering the fact that nobody considered the relational model difficult according to the questionnaire survey discussion later, 12.5% of the students considered SQL difficult and 37.5% of them considered Access objects complicated. From among the topics the students found the PHP functions (50%) the most difficult one. This result can be explained by the fact that it has fundamental importance in the understanding and learning of the relational model and SQL regarding whole topic, and students agreed on this too. The OOP technique explains the higher number of solving the Access objects test that students

faced with first now. According to our opinion to understand PHP functions is not difficult however to remember them maybe more complicated which can be the cause of the tough evaluation by students.

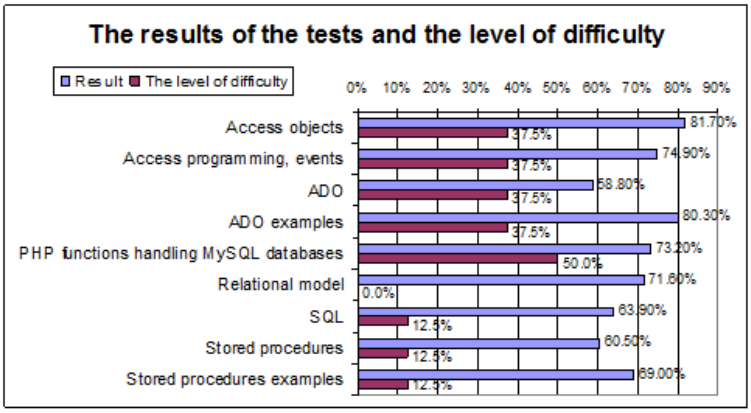

Figure 1: The results of the practising tests

With the help of data mining method we analyzed also if someone solved a test which other tests were solved by the same person too. By generating associative rules we were looking for two elements rules with at least 80% support and at least 90 % confidence level [15]. Figure 2 shows the results.

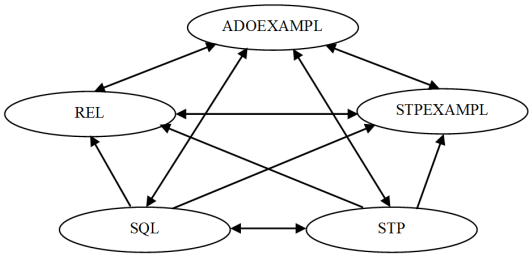

Figure 2: Associative rules graphically

Beside the relational model (REL) and SQL test (SQL) the sample procedures containing placeCityADO examples (ADOEXAMPL) and stored procedure examples (STPEXAMPL), and the stored procedures (STP) tests were solved by students with a high probability. The result is in line with our expectations since we believed that beside the relational model that has fundamental importance and SQL tests the overview of example procedures, interpretation of them, answering their questions requires practice according to the students too.

We looked for an answer for the question how much time did the students devote to the solution of the tests and what kind of score they realized. On the one hand we depicted the scores on a diagram comparing to the time devoted to the test

solution – see figure 3 – , on the other hand we looked for three clusters based on Euclidian absolute distance, into which the data can be assigned.

For clustering it was necessary to clean the data, because in case of unfinished attempts the time devoted to a solution was unreal high. We substituted these values with the average of the times devoted to the finished attempts of the certain test [15]. Table 4 contains the result of clustering.

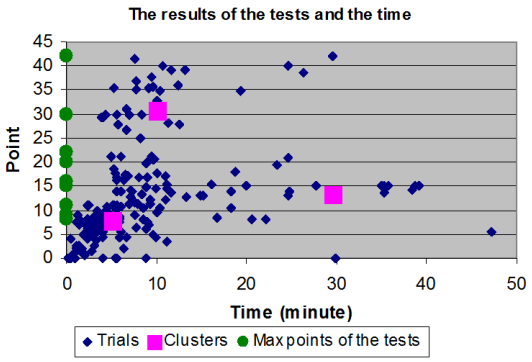

Figure 3: Scores in function of the time devoted to the test solution

Cluster	Score	Standard deviation	Time (minute)	Standard deviation	Trial	Distribution
Cluster0	30.74	6.98	10.1	5.7	39	19.4%
Cluster1	13.37	4.63	29.5	8.4	22	10.9%
Cluster2	7.88	4.8	5.1	3.5	140	69.7%

Table 5: The result of score-time clustering

The bigger sized squares show the result of the clustering on Figure 3, on axis y the dots mark the maximum score of the tests. At the analysis we took the examination tests into consideration as well.

Based on comparing the result of the clustering with the time devoted to the test solutions we can say that cluster 0 includes the examination test and ZH1_practising test, cluster 1 includes placeCityADO examples and the cluster 2 includes the rest of the tests.

The time devoted to the solution of examination tests compared to the 45 minute time constraint is very short, which can be caused by the fact that students managed to prepare well with the help of the practice tests that seems to be justified by the results. Notable that student spent an outstanding amount of time with CityplaceADO examples test (29.9 minutes). The reason of it may be the complexity of the placeCityADO object model which is the most difficult topic even according to our judgement as teachers too.

As a teacher we consider the time devoted to the solution of the tests included in cluster 2 short. The average number of questions here is 14.5 in these tests so

for one answer 21 seconds are available on average. This period of time seems too short for students to look for the correct answers in course books and educational substances so based on this we think that students primarily study based on the correct and wrong answers showed after finishing the tests. This is also confirmed by the fact that only one third of students read all educational substances.

We also analyzed that in those cases when students solved a test more times at which trial did they reach the best results. According to Table 5 in 67.35% of the cases the result of the last trial was the best one, so we may assume that the majority of the students who solved a certain test many times practised until they reached the best result.

Trial	**Number**	**Distribution**
First	12	24.5%
Middle	4	8.2%
Last	33	67.3%

Table 6: In how many trial were they attend the maximum score

We tried to generate a decision tree. According to this, if the number of the trials is more than one, then with 52% support and 67.3% confidence the student achieves the best result in the last trial [15].

5. Question analysis of the Moodle tests

The tests implied two kinds of question type, multiple-choice and pairing questions. During the analysis we examined that what question type resulted what kind of scores. We may say that students solved the pairing questions correctly in a higher proportion in all tests.

At the tests we examined the given answers item by item in order to find out what areas of certain topics require more explanations, practice in the future. We consider those topics to belong here in which students reached worse results than the average result of the test, or received credit 2 or 3. We summarized the topics in Table 6 by tests.

Test	**Topic**
Access objects	Filtering, handling of the forms
Access programming, events	Referencing in OOP, naming of the event handling procedures, the occurrence of events
ADO	The parameters of ADO objects, sequential processing of the record sets
ADO examples	Right parameterising of the connection string
PHP functions handling MySQL databases	Running of a SQL statement which doesn't return result
Relational model	Functions of the primary and the foreign key, integrity constraints
SQL	Grouping of the SQL statements, functions of the clauses of SELECT statement, grouping, join

Stored procedures	Functions of the control flow statements, difference between return and retruns key words, triggers, processing with cursor
Stored procedures examples	While statement, processing with cursor

Table 8: Problematic topics by test

6. Evaluation and results

The students had to solve two computer based tests during the course and it was necessary to prepare homework once as well. We summarized the results of the tests in the Table 7.

Test	**Level of difficulty**	**Average point**	**Max point**	**Average time**	**Result**	**Mark**
ZH1	easy	37.4	42	14.2 minute	89.0%	5
ZH2	easy	27.9	30	7.7 minute	93.1%	5
Homework (Access application)	difficult	13.56	30	1.9 day	45.2%	1

Table 9: The results of the exam tests and the homework

We asked the students in a survey which topic was considered a difficult one and which one did they find simple enough. There isn't any considerable relation between the difficulty and the efficiency, the correlation is only 0.175.

The homework is suitable tool to measure how the students are able to apply the learned knowledge in practice on their own. The task was to create an Access database and students had to create forms for the insert, update and delete operations. Certain primary keys had to be generated with a help of a program and the data had to be checked through event handling procedures. A task was to create SQL queries and reports too. We decided to use Access since it was available for all students. Other tasks would have required the installation of database management systems or client programs which could have caused a problem for some students.

The students considered certain subtasks of the homework as difficult. Unfortunately those activities are proved to be difficult which we aimed to teach the most – generate value for the keys by program, data check by program.

7. Questionnaire survey

We asked the students to fill a questionnaire on the end of the half-year. [13] According to this the main motivation for attending the course were the acquisition

of further database knowledge (67%) and to deepen the already existing database knowledge (33%). The development of the programming skills was not strong motivation factor (22%).

The 67% of the students dealt with database management already previously. They dealt with data modeling (11%), with interactive database management (22%), and SQL language (44%) and database programming (22%). Most of them used Access (55%), less of them tried MS SQL Server (11%) or MySQL-t (22%). One student worked also with SQLite and PostgreSQL database management systems.

Everybody studied programming before the attending the course. By themselves they studied the Pascal, the C, the C++, the Visual Basic, the PHP and the Java program languages. All of them studied the Visual Basic language during their university studies; one of them studied Java too. The students evaluated their own programming knowledge for 2.44 on a five degree scale, 55% of students thought that this knowledge is sufficient to fulfill the requirements of the course.

44% of students solved the practice tests of Moodle system two times, 22.2% of them solved it three times while the others solved the tests only once or not at all. The students evaluated the usefulness of tests for 4.66 on a five degree scale. 33.3% of them have read all the educational materials, while 66.7% of the students read them only partially. They evaluated the usefulness of the materials for 3.44 on a five degree scale. 77.8% of students solved practice programming tasks while 22.2% of them never did any. According to students the usefulness of these tasks is 3.44 on a five degree scale.

Students dealt with the preparation of home work 1.9 days on average. 66.7% of the students stated that they did not have sufficient database management knowledge to solve the homework. 33.3% of the students used both Access and Access programming educational materials while the others only one of them. The 66.7% of students did not consider the level of their homework appropriate. Only 25% of the students required to take part in a consultation with the teacher.

Majority of the students think that their database management knowledge has been expanded (66.7%) and their programming skills had developed (100%).

We asked for detailed evaluation from the students about what did they like and what not during the course. Some students liked the SQL, the homework, the examples, the topics in general. More people mentioned the detailed explanation and the teacher helpful attitude as an advantage. Many people did not like the slow computers, the server problems, and some students did not like topics of ADO and Access programming.

8. Summary

All together we can consider the course successful. The result of students reached 4.09 which reinforce the success. All students think that the received evaluation matches the reality and if there would be a possibility 89% of the students would choose to attend the course again.

We plan to write additional test questions, primarily in the stored procedures and placeCityADO topics.

There are two solutions to avoid the problem of insufficient time during the course. A Database Management and a Programming Knowledge course could be introduced as eligible C subjects as it would increase the number of those students who have deeper knowledge in these topics. On the other hand it would be necessary to teach the SQL language in the frame of separate consultation classes. The time released would be sufficient for the substance parts were left out.

The preparation of the homework would be a task from the beginning of the course with the help of regular consultations offered by the teacher. The students would be inspired for regular work by deadlines for certain subtasks.

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