Impact of the Self-training Over Formative Assessment in SQL Part of University Database Course

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Abstract. Nowadays databases are the main technology for storing and managing data in contemporary information systems at different levels. Despite the growing popularity of NoSQL stores, relational databases continue to be the main technology at the backend of the information systems, and building SQL knowledge and skills is an important part of the preparation of the students in ICT area.

In general, to be effective in building of the appropriate knowledge and skills in database area, the university database courses have to make focus not only on the theoretical lectures but also to implement practical sessions in real DBMS environments (database sandboxes) to demonstrate practical implementation of the database theory. Providing effective SQL self-training is also an important part of building appropriate knowledge and skills.

In this paper one approach for structuring a database course focused on extended formative assessment during the semester is presented. As part of assisted self-preparation an automated self-trainings quizzes for SQL part of the course are provided and students are encouraged to take part in them. It is found that the students that were more active in solving self-training quizzes were more successful in formative assessment quizzes. Also, it is found that the students' achievements in SQL formative assessments have no statistically significant difference with achievements in summative assessment in the corresponding SQL part of the final exam.

Keywords: SQL · database course · automated self-training · formative assessment

1 Introduction

Nowadays, majors and minors in ICT field have become very popular and many young people want to build their successful career in this area. Database courses are an important part of any contemporary ICT curriculum [1], so teaching successfully databases is one of the important basics for building effective body of knowledge and skills of the students in ICT area.

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In general, the classic database course consists of two major parts – Database design and relational database querying and managing using Structured Query Language (SQL). According to the literature review, presented in [2], the following basic subsets of SQL are commonly considered in universities database courses:

- Data Manipulation Language (DML):
  - SELECT, FROM, WHERE, GROUP BY, HAVING, ORDER BY, INSERT INTO, VALUES, UPDATE and DELETE clauses;
  - different types of JOINs with variation in implementation;
  - predicates like IN, EXISTS, LIKE, BETWEEN, and IS NULL/NOT NULL;
  - standard aggregate functions MIN, MAX, AVG, SUM, and COUNT.
- Data Definition Language (DDL):
  - CREATE, ALTER, and DROP statements on tables, views, and users.

In fact, as result of the exponential growing of the data volume to be stored, managed and queried in Internet, NoSQL databases are becoming more and more common in big data management and appropriate topics are included in contemporary database syllabuses. As side effect of this, students prefer to learn these more modern topics, and SQL looks obsolete. Moreover, the Object-Relational Mapping (ORM) techniques and libraries hide the relational database behind business logic and makes SQL to look as not needed. As a result, many non-experienced (and not only) developers think about the relational database as a pure "black box" that simply works and nothing more. In general, this approach is focused only on the semantical correctness of the queries produced by the ORM, without taking into account their effectiveness in execution.

It is clear that not all of the students will be in the situation to create manually complex SQL queries to solve complicated tasks effectively, but the basic knowledge and skills about relational database design and management using SQL are still needed as important part of the education in ICT area.

2 Related Studies

In higher education ecosystem feedback for self-training materials and formative assessment by default is a duty of the instructor. In many cases, the feedback is only the tasks' grading. It is accepted in general, that feedback helps students to increase their performance [3, 4].

For every educational subject the formative assessment is an important part of the educational process. Formative assessment is "a range of formal and informal assessment procedures employed by teachers during the learning process in order to modify teaching and learning activities to improve student attainment" [5, 6] The formative assessment requires regularity which provides monitoring of the learning process of every student. Formative assessment could be conducted in different forms: tests, homework assignments, solving of simple or complex practical tasks, etc.

Unfortunately, manual feedback reduces the capacity of the instructors to grade students' works and/or send feedback on time [7] which is important for formative assessment and is valuable for the students. This problem grows when the instructors have to grade manually self-training tasks, directed to help students' preparation for formative or summative assessment. In the situation with large number of students, and/or many self-trainings and formative assessment quizzes, the automatic grading is an important part of the education process and is very effective in case of electronic communication [8, 9]. It also helps instructors to be more effective by reducing workload [10].

In the study of [11] authors consider students' opinion regarding formative assessment in database course. The main research tool is survey of student's attitude. The authors apply two forms of formative assessment "interactive questionnaires during class time and self-assessment of lab practices." According to this study student's perception of both forms of feedback are positive and their application could be in distinguished forms of education – face to face, hybrid, or in online environment.

In order to be effective for students' self-training, SQL tasks have to be automatically evaluated for correctness, i.e. students have to receive their assessment results immediately after submission of the solutions. According to [12], there are five types of tasks which are suitable for automatic formative assessment:

- Yes/No and multiple choice questions;
- Creating SQL queries from scratch in order to obtain the desired output according to given database schema and (optionally) state;
- Filling the missed part/s in a template of SQL query to obtain a specified result from a given database schema and optional state;
- Selecting the appropriate SQL query from the list of queries to obtain a specified result from a given database schema in optional state;
- Evaluation of the SQL query result (number of rows returned) from a given database schema and state.

Regarding the assessment of SQL an "automatic test form assembly system so as to assist the lecturers in performing the mastery learning instruction in the Oracle SQL certification course" is performed in [13]. This system is based on numeric methods for automatic generation of formative tests with multiple choice items.

Authors of [14] analyze huge number of students' individual or collaborative homework assignments. Automatic system for grading of SQL queries created from scratch is used for formative assessment. The main goal is to identify the typical syntax or semantics errors during solving of SQL problems.

3 Research Design

3.1 Experimental Design

Course Structure. The grading outcomes used in this study were collected in the SQL part of the one semester database course directed mainly to students in the area of Information systems. The course is structured in two major parts:

- Database design:
  - Introduction to databases;
  - Data modelling using Entity-Relationship Diagram and UML Class model;
  - Relational and other (NoSQL) database models,
  - ER/UML to relational mapping
  - Normalization;
- Structured Query Language (DDL and DML):
  - CREATE, DROP, ALTER, INSERT, DELETE, UPDATE;
  - Single table queries (SELECT-FROM-WHERE-ORDER BY);
  - Single table queries (SELECT-FROM-(WHERE)-GROUP BY-HAVING);
  - Multiple table queries (JOIN);
  - Multiple table queries (Sub queries and SET operators).

Additionally, at the end two extra topics are considered shortly – Transaction processing, and Query optimization and indexing. Also, after each of the major part at least one class is dedicated to overall revision.

Totally seven formative quizzes are conducted and the six best results are counted as part of the final grading. Additionally, as part of the formative assessment two personal home works – first over database design part and second – over database implementation and SQL are conducted too.

The seven of the topics mentioned above, are structured as follows: one theoretical lecture class followed by practical session class and formative assessment over this topic on the beginning of the next topic's lecture class.

In Database design part, preparation for formative assessment was supported with example tasks for self-training and on ground and/or online consultation with the lecturer.

Four of the SQL topics taught in this research were strictly conducted in the style mentioned above – theoretical lecture class with examples and simple practical tasks, followed by practical session class with tasks' solution in database sandbox. Also, after the SQL practical sessions, the students were supported with self-training quizzes with automatic grading for preparation for the following formative assessment quizzes on the topic. At the end of each major part at least one class is dedicated to overall revision.

Summative assessment is conducted in two parts – midterm exam over database design part and final exam over SQL part.

Learning Materials Design. The entire course is conducted in blended learning mode. Classes are taught in on-ground mode and is supported with online learning materials and communication environment by learning management system.

Also, the SQL part of the course is supported by database sandbox which implements the philosophy that all students must have the same database schema and state during the lectures and practical sessions to be able to obtain demonstrated results or to experiment in standardized environment. Database sandbox can be deployed in Oracle DB, MySQL, MariaDB or MSSQL Server on local or cloud database instances using appropriate SQL scripts. In general students are encouraged to use the free web-based service LiveSQL

[15] provided by Oracle, mainly because of its usefulness, zero maintenance efforts and SQL standard compatibility.

Database schema and state used in the course is a modified version of the example database from [16]. The schema is presented in Fig. 1, using notation from [17].

```
Salespeople (snum, sname, city, com)
Customers (cnum, cname, city, rating, snum→Salespeople.snum)
Orders (onum, amt, odate, snum→Salespeople.snum, cnum→Customers.cnum, dcity)
Summary (onum, amt, odate, sname, cname, dcity)
```

Fig. 1. Database schema used in course database sandbox, trainings and formative assessments.

The schema consists of three tables and one view:

- Salespeople table holds information about salespeople, (id, name, city, commission) filling the orders
- Customers table holds information about customers (id, name, city, rating, salesperson attached), placing the orders.
- Orders table holds information about orders (id, amount of the order, salesperson id, customer id, date and place of delivering).
- Summary is a view, in which salespeople snum and customers cnum are replaced by sname and cname using joins between Salespeople, Orders, and Customers.

The original Salespeople-Customers-Orders database schema is modified with one new field in Orders table to represent place of the order's delivering. Original state consists of six records in Salespeople table, seven records in Customers, and ten records in Orders and in modified state, used in the sandbox is extended with two new records – one salesperson without orders filled and attached customers and one customer without orders placed. Also the view Summary is added in the schema to increase illustration power of the examples in single table queries topics and subtopic about correlated subqueries. At all, these modifications extend the capability of the database sandbox to be used in more interesting example tasks.

Tasks with evaluation of the SQL query result (number of rows returned) from a given database schema and state are used in self-training tasks sets, formative assessments quizzes and in summative SQL assessment in Final exam. All training tasks sets, quizzes and final exam are implemented and automatically graded in the LMS used to support blended learning. This approach was not chosen solely because of the possibility of automatic evaluation in the contemporary LMS. In fact, evaluation of the result of the query against particular database schema and state creates more deep understanding about logical way of query execution and intermediate datasets or scalars pipelined between query's parts.

To be more suitable for the students, the training tasks are based on database sandbox schema and state used in lectures and practical sessions. Students were able to check each training task for correctness and to experiment with tasks' variations. In fact, formative assessment quizzes use the same tasks and the same database schema as in training tasks, but with variation of the database state. In this way, the students are familiar with the

tasks and the database schema (Fig. 2), but they have to apply their knowledge and skills to obtain results in a different database state (Fig. 3).

Table Orders

ONUM	AMT	ODATE	CNUM	SNUM	DCITY
3001	18.69	03-OCT-14	2008	1007	London
3002	1900.10	03-OCT-14	2007	1004	London
3003	767.19	03-OCT-14	2001	1001	Barcelona
3005	5160.45	03-OCT-14	2003	1002	London
3006	1098.16	03-OCT-14	2008	1007	Madrid
3007	75.75	04-OCT-14	2004	1002	London
3008	4723.00	05-OCT-14	2006	1002	London
3009	1713.23	04-OCT-14	2002	1003	London
3010	1309.95	06-OCT-14	2004	1002	London
3011	9891.88	06-OCT-14	2006	1001	Barcelona

How many rows will contain the output of the following query?

```
SELECT snum, SUM(amt) AS Money
FROM orders
WHERE amt > 2500
GROUP BY snum;
```

(Training task, the correct answer is 2)

Fig. 2. Example of a training task used in the course.

Table Orders

ONUM	AMT	ODATE	CNUM	SNUM	DCITY
3001	2200	30-NOV-19	2008	1007	Barcelona
3002	700	30-NOV-19	2007	1004	San Jose
3003	150	30-NOV-19	2001	1001	Barcelona
3005	1200	30-NOV-19	2003	1002	London
3006	250	30-NOV-19	2008	1007	Madrid
3007	9800	01-DEC-19	2004	1002	Rome
3008	1300	02-DEC-19	2006	1002	New York
3009	4500	01-DEC-19	2002	1003	Berlin
3010	1300	03-DEC-19	2004	1002	Madrid
3011	5300	03-DEC-19	2006	1001	Barcelona

How many rows will contain the output of the following query?

```
SELECT snum, SUM(amt) AS Money
FROM orders
WHERE amt > 2500
GROUP BY snum;
```

(Formative task, the correct answer is 3)

Fig. 3. Example of the task, used in the formative assessment.

Frequent change of the database state used in formative assessments prevents students from non-academic behavior. Also, the database schema used in the final exam (Fig. 4) is similar to schema used in formative assessment and is public, but four to six database states are used in the exam tasks for the same reason.

Salespeople and Customers tables are the same as in schema in Fig. 1. Orders table is modified and holds information about orders (customer, salesperson, date and place of delivering). Three additional tables are added:

```
Salespeople (snum, sname, city, com)
Customers (cnum, cname, city, rating, snum→Salespeople.snum)
Orders (onum, odate, snum→Salespeople.snum, cnum→Customers.cnum, dcity)
OrderItems (onum→Orders.onum, fnum→Fruits.fnum, quantity)
Fruits (fnum, fname, ftype, fprice, vnum→Vendors.vnum)
Vendors (vnum, vname, city, comm)
```

Fig. 4. Database schema used in summative assessment (final exam)

- Vendors table holds information about vendors, (id, name, city) supplying fruits;
- Fruits table holds information about fruits (id, name, type, price, and vendor) which are supplied and are available for ordering.
- OrderItems table holds information about items in each order – kind of fruit and quantity ordered.

4 Analysis of the Results

4.1 Main Research Questions and Hypotheses

The research questions which leaded this study include:

RQ1. Is there difference regarding the achieved results about SQL knowledge and skills during the formative assessment quizzes (Q_1, Q_2, Q_3, Q_4) and summative assessment in Final exam (FE)?
RQ2. Did number of trainings done before formative assessment quizzes influence to the results achieved in formative tests?

4.2 Data Processing and Analysis

Data are processed by open statistical software – Jamovi [18]. All calculations are performed with level of significance $\alpha = 0.05$.

The descriptive statistics of variables related to number of trainings in each training session before quizzes are presented on the Table 1. The notation is as follows: NB_i means number of trainings during the i training before the i^{th} quiz, where $i = 1, 2, 3, 4$.

The descriptive statistics of variables related to the quizzes results are presented on Table 2. The used notation is like number of trainings: Q_i – means points achieved during the i^{th} quiz, and FE_100 variable contains the points relevant to Final exam part calibrated to 100.

For testing normality of the distributions Shapiro-Wilcoxon test is performed. All variables have not normal distributions – Shapiro-Wilk $p < .001$. Therefore, and because of low number of participants (28) we use non-parametric tests.

The variances in some of the variables are relatively high because there were one or two students with extremely high number of trainings.

For comparison of the variables related to number of trainings and comparison of variables related to quiz achievement results we applied repeated measures ANOVA (Non parametric) based on Friedman test. The results show that there is statistical significant difference among the number of trainings Friedman test $\chi 2(10{,}3, df = 3, p = 0{,}016)$. The

Table 1. Descriptive statistics for variables – number of trainings before formative quizzes.

	NB_1	NB_2	NB_3	NB_4
No of students trained	28	28	28	28
Missing	0	0	0	0
Mean	3.61	1.07	4.36	3.29
Median	1.50	0.00	2.00	3.00
Mode	.00	.00	.00	.00
No of trainings	101	30	122	92
Standard Deviation	5.12	1.44	7.21	3.58
Variance	26.2	2.07	52.0	12.8
Minimum	0	0	0	0
Maximum	23	5	30	13
Shapiro-Wilk W	.714	.767	.655	.827
Shapiro-Wilk p	<.001	<.001	<.001	<.001

Table 2. Descriptive statistics for variables achieved points in quizzes.

	Q_1	Q_2	Q_3	Q_4	FE_100
No of students tested	28	28	28	28	28
Missing	0	0	0	0	0
Mean	83.9	74.3	69.2	75.4	77.8
Median	100	75.0	81.0	81.0	80.0
Mode	100	100	100	81.0[a]	80.0
Standard Deviation	24.5	26.6	34.1	21.2	16.8
Variance	599	707	1163	451	284
Minimum	0	19	0	19	20
Maximum	100	100	100	100	100
Shapiro-Wilk W	.714	.845	.805	.892	.877
Shapiro-Wilk p	<.001	<.001	<.001	0.008	0.004

pair ways comparisons show that number of second trainings is statistically significant different from the number of all other trainings ($p < 0{,}05$) (Table 3). In fact, the number of trainings before second quiz are smaller than other the number of trainings before other tree quizzes, that reflects to other next results.

RQ1. For the answer of the RQ1 we applied Repeated Measure ANOVA(Non-parametric) to compare achievements in all five tests. The Friedman test shows $\chi 2 = 4.72$, $df = 4$, $p = 0.317$ and we can summarize that there is no difference between

Table 3. Pairwise Comparisons NB/NB (Durbin-Conover).

	Statistic	p
NB_1-NB_2	3.000	0.004
NB_1-NB_3	0.480	0.632
NB_1-NB_4	0.360	0.720
NB_2-NB_3	2.520	0.014
NB_2-NB_4	2.640	0.010
NB_3-NB_4	0.120	0.905

achievements of the students in conducted five tests. The Jamovi software also applies Pairwise Comparisons (Durbin-Conover). The results show (see Table 4) that there is no statistically significant difference between pairs of tests. For all pair comparisons $p > .05$.

Table 4. Pairwise Comparisons Q/Q (Durbin-Conover).

	Statistic	p
Q_1-Q_2	1.470	0.144
Q_1-Q_3	1.746	0.084
Q_1-Q_4	1.240	0.218
Q_1-FE	1.975	0.051
Q_2-Q_3	0.276	0.783
Q_2-Q_4	0.230	0.819
Q_2-FE	0.505	0.614
Q_3-Q_4	0.505	0.614
Q_3-FE	0.230	0.819
Q_4-FE	0.735	0.464

RQ2. For RQ2 we grouped students in two groups for every quiz according to the mean of the number of trainings before relevant training. For every quiz the groups are noted with 1, if the number of trainings is greater than mean, and mentioned with 2, if the number of trainings is less than mean.

The H_0 hypothesis for all cases is that the achievements of students in group with more trainings are less than achievements of students in group with less trainings against the alternative hypothesis H_α – The achievements in group with more trainings are higher than achievements in group with less trainings than mean of trainings. The students achieve higher results if they do more trainings before the quiz.

Table 5. Results from application of Mann-Whitney U test.

Quiz	Group	No	Mean	Median	U-Statistic	p	Effect size r_{rb}
Q_1	1	8	98.1	100.00	41.0	.015	.488
	2	20	78.3	82.5			
Q_2	1	9	75.9	100.00	77.5	.350	.0936
	2	19	73.5	75.0			
Q_3	1	6	93.7	100.00	33.0	.029	.500
	2	22	62.5	81.0			
Q_4	1	10	85.5	81.0	54.0	.040	.400
	2	18	69.8	63.0			

Due to non-normality distribution of the achievements for all quizzes we apply non parametric tests for independent samples – Mann-Whitney U test (see Table 5). The plots are presented in Figs. 5, 6, 7, and 8.

The data show that we can accept alternative hypothesizes for Q_1 ($U = 41$, $p = .015$, $r_{rb} = .488$), Q_3($U = 33.0$, $p = .029$, $r_{rb} = .500$), and Q_4($U = 54.0$, $p = .040$, $r_{rb} = .040$) – students that performed more trainings than average, achieved higher results than students that have less trainings before the quiz with moderate to high practical significance. For the Quiz 2 we did not find relation between the number of trainings and achievements Q_2($U = 77.5$, $p = .350$, $r_{rb} = .0936$). Probably because in fact in this quiz all students performed relatively less trainings before the quiz, than in the periods before other tree quizzes.

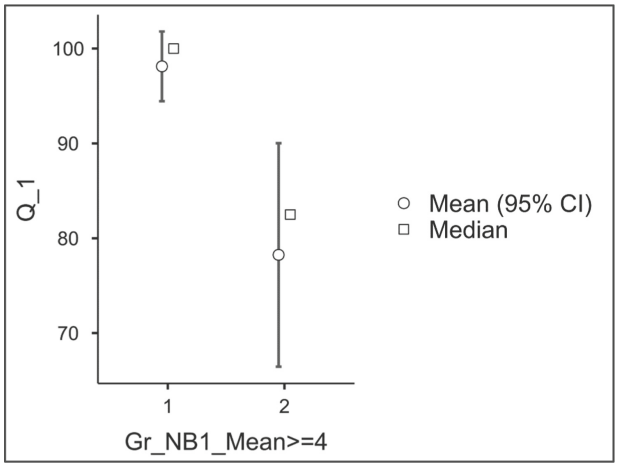

Fig. 5. Distribution of Achievements of Q_1 according to Number of trainings more or equal than 4.

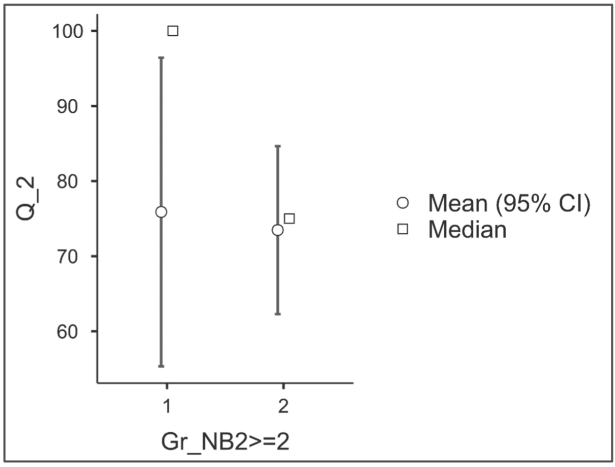

Fig. 6. Distribution of Achievements of Q_2 according to Number of trainings more or equal than 2

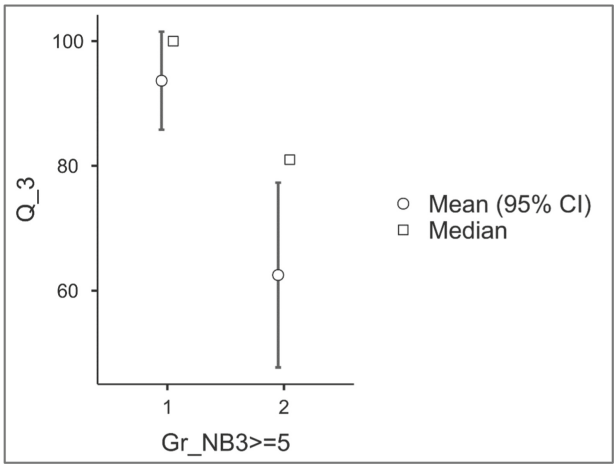

Fig. 7. Distribution of Achievements of Q_3 according to Number of trainings more or equal than 5

These results give as reasons to accept the Hypothesis that number of trainings before the formative quizzes in above discussed model of application of self-trainings in SQL queries influence positive to the students' achievements in SQL.

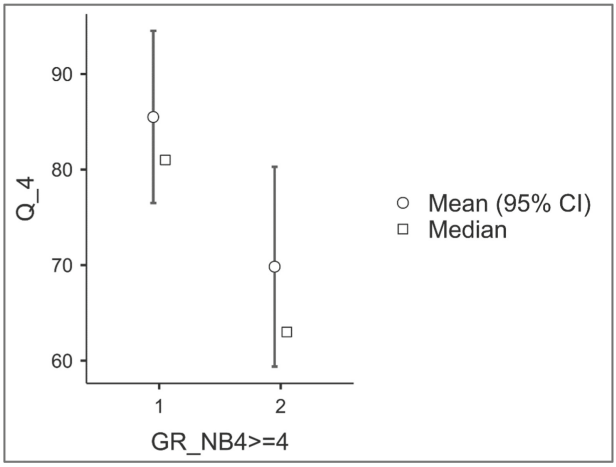

Fig. 8. Distribution of Achievements of Q_4 according to Number of trainings more or equal than 4

5 Conclusions

In this paper one approach for structuring a database course focused on extended formative assessment during the semester is presented.

The limitations of the study are related to the small number of students participating in pilot implementation and study of the approach.

As part of assisted self-preparation an automated self-trainings quizzes for SQL part of the course are provided and students are encouraged to take part in them. It is found that the students that were more active in solving self-training quizzes were more successful in formative assessment quizzes. Also, it is found that the students' achievements in SQL formative assessments have no statistically significance difference with achievements in summative assessment in the corresponding SQL part of the final exam.

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