Online way to learn SQL

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Abstract. The new version of Hungarian National Base Curriculum (NAT 2020) makes many changes in public education, including many innovations in the field of Computer Science Education (newly known as Digital Culture). NAT 2020 makes knowledge of the Structured Query Language (SQL) mandatory for students in the advanced final examination. In the future, students must be able to independently formulate SQL statements based on the task without the help of graphical tools (query builders) in the advanced final exam. This poses new challenges for both students and their teachers.

Based on the changes in the Hungarian National Base Curriculum, we have already created an educational portal called kodolosuli.hu, which is a great success among both students and teachers related to teaching and learning programming languages (Java, C++, CSharp and Python)[2]. Based on the experience of the kodolosuli.hu portal, we thought it would be advisable to design and develop a new web portal related to relational database management. Our goal with the design and development of sqlsuli.hu was to give the teenage generation the opportunity to learn the basics of relational database management and SQL in a playful and effective way. In 2022, after continuous development, the site became available for free. In Hungary, this type of portal is not available, apart from our sqlsuli.hu portal, which was developed for people under the age of 18.

The framework has an extensive grader tool that helps students test their knowledge in some automatic way, so the portal provides a flexible learning way. The test databases are based on Harry Potter and Star Wars data, which is expected to increase students' engagement and motivation for learning. The course is available in the Hungarian language.

Keywords: SQL, Learning Management System, final examination, online platform

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1. Introduction

The structured query language (SQL) is the query and control language of relational database management systems. Relational database management systems provide SQL interface to perform each task, which means that SQL is a very rich language, providing several statements and structures from creating users to formulating very complex queries. We can divide the SQL into four different parts based on the functionality:

- Data Control Language (DCL): consists of the SQL commands that can be used to manage the users and their privileges belonging to the database and its objects.

- Data Definition Language (DDL): consists of the SQL commands that can be used to manage (create, modify, delete) database objects.

- Data Manipulation Language (DML): consists of the SQL commands that can be used to manage (add, update, delete) data content of the tables.

- Query Language (QL): consists of the SQL commands that can be used to query of the content of tables from different viewpoints.

- Transaction Control Language (TCL): consists of the SQL commands that can be used to manage transactions in the database.

If we wish to to be successful in database management in public education, we need to know the DDL, DML and QL elements of SQL. In most cases, DCL regulation is a database administrator task.

In Hungary, the educational content to be taught in public education and the main teaching methodology are regulated by the National Base Curriculum (NAT), which has been updated several times by the government in recent years. The new Hungarian National Base Curriculum (NAT 2020) makes many changes including many innovations in the field of Computer Science Education (newly known as Digital Culture). NAT 2020 makes knowledge of the Structured Query Language (SQL) mandatory for students in the advanced final examination. In the future, students must be able to independently formulate SQL statements based on the task without the help of graphical tools (query builders) in the advanced final exam. If we examine the content of the base curriculum, we can conclude that it will be difficult to meet the expectations in classroom conditions: in high school, only 25 lessons (1 lesson is 45 minutes) are spent on database management. The emerging new situation and new expectations present both students and teachers with new challenges.

Learning a programming language may be more difficult than learning SQL statements, meanwhile acquiring knowledge of SQL for students under the age of 18 is also time-consuming and not as easy as one might think. In the school, teachers try to teach the students to think in an algorithmic way, but the declarative characteristic of SQL requires the opposite thinking methods. It is quite interesting

how can we teach the students in public education two different thinking methods in one hour per week. This is clearly an extremely difficult task. On the one hand, it basically requires teacher supervision, similar to learning other content.

If we would like to learn SQL independently in some practical way without any teacher supervision, we can install some free database management system (like MySQL or PostgreSQL). There are a lot of vendors whose database management systems can be used to learn SQL by working with them. But for beginners these systems are not very helpful or in some way might be very harmful too. Database management systems are only limited to providing feedback on syntax errors [7]. It means that if we made a logical error, these systems do not show error messages. Accordingly, we can learn techniques in database management that we believe are correct, but in the future, they will produce an incorrect set of results. Realizing these problems, in the late 1990s and early 2000s, researchers developed various tools that provide a way to learn SQL [9].

Several researchers have been involved in teaching SQL: Al-Shuaily and Renaud proposed applying SQL patterns [10], Mitrovic developed a Knowledge-Based Teaching System for SQL [6], Quer et. al developed a software tool, LearnSQL (Learning Environment for Automatic Rating of Notions of SQL), that allows the automatic and efficient e-learning and assessment of relational database skills [8]. Garner and Mariani developed a graphical user interface centred around the textual translation of a query which has the potential to improve the way in which users gain an understanding of SQL [3]. Although books and course notes in Hungarian and online courses in English are available, it seems insufficient for most secondary school students. An early example SQLTutor in which the developers tried to examine the content of queries and make feedback belonging to the logical problems [6]. Another system, called eSQL concentrates on the sequences of steps that solve SQL problems. In this system during the implementation, we get sequences of images to describe what happened during the execution [4]. Learn-SQL is also an online SQL tool in which users' solution are checked by automatically in a logical way, so it can be very useful to learn SQL online [1].

Recently, books and lecture notes in Hungarian and online courses in English are available, which seem insufficient for most secondary school students. There are some portals that provide learning SQL playfully such as SQL Island [11] or SQL Murder Mystery [5]. Portals such as Udemy.com, CodeAcademy, tutorials on W3Schools or Tutorialspoint that teach SQL in an interactive way in English might be useful. In Hungary, this type of portal is not available, apart from our sqlsuli.hu portal, which was developed mainly for people under the age of 18.

2. Learning Management System

We started the development in 2021, and at the end of the year, we implemented our web portal which can help students to learn the main concept of the structured query language and relational data model. In 2021, the demo version of the Learning Managment System was published, and in 2022, after continuous development,

the site became available for free.

The webportal was created by using our own educational framework, which was developed using the PHP5 programming language and the MVC design pattern. We use the MySQL relational database management system to store the data. The portal provides the key features of Learning Management Systems.

Currently, there are three types of users who can access the system; students, teachers and the administrator. Students can reach the curriculum and they can check the progress and the solutions that they submitted earlier. The teachers can also use the system for learning and they access their students' progress as well, if the students enable this option. The administrators have full access to both the materials and the users' data. The administrator can create and manage new learning objects or tasks and they also can read all information about the students' progress and solutions.

The most interesting parts of the portal are the course editor and the grader subsystem.

2.1. Course editor

In the course editor subsystem, we can create new online courses with our own teaching content.

Courses can be divided into chapters in the system, which serve as logical containers. The series of lessons can be recorded in these chapters. A lesson is a teaching object that the student sees on one screen at the same time.

We currently distinguish between three lesson types: independent lesson material, independent task and lesson material with tasks.

During the preparation of the independent study material, we use the entire screen to present new knowledge. During the creation of the independent lesson material, we can use text minds, audio-visual content and attachments. This lesson type is used to assess our students' SQL knowledge. Applying the lesson material with task types, (Figure 1), we can also create tasks next to the curriculum, which appear on the right side of the screen. After reading the study material, students must complete the related tasks in order to move on to the next lesson. These tasks are typically short SQL statements that focus on a specific piece of text. In the case of the independent task (Figure 2), the entire screen is used to introduce the task that the student must solve in order to move on. These types of lessons typically occur at the end of each chapter with the aim of integrating the knowledge acquired in the chapter into more complex tasks.

2.2. Grader subsystem

In addition to the learning objects and materials, another important element of the web portal is the grader. With the help of the grader system, students have the opportunity to test their knowledge automatically.

Testing queries is particularly challenging, as there are several correct solutions to the same problem in SQL. A well-functioning learning tool must also ensure

Figure 1. Lesson material with tasks.

the acceptance of several correct solutions since motivation is greatly reduced if a tool classifies a completely correct solution as incorrect. Accordingly, we discarded the use of only syntactic checking. A textual check of the specified query is also not expedient, because then we only accept the solution defined by us. In order to test the queries, the solution of the task must be specified when recording the tasks in the framework. The students' SQL solution is first run in the database by a database user with limited privileges. If the query execution is successful, we run the administrator solution. The result sets of the two solutions are compared, and if they completely match, the solution is accepted, otherwise, the solution is rejected and the error is indicated. Students do not see the contents of the data tables, so they cannot use tricks to generate the correct solution because they do not know the expected output. When creating the portal, we tried to focus on the fact that the error message helps the user to be able to correct their solution during each incorrect solution. Possible error messages that may appear in the course material are:

- *The query contains syntax errors.* We receive this error message if we create a query that does not comply with the SQL syntax rules, so the query cannot be executed.

- *Database user does not have enough sufficient privileges to execute it.* The

Figure 2. Independent task.

query does not contain a syntax error, but the database user does not have sufficient privileges to execute it.

- *The number of columns queried is incorrect.* The query is correct and gives a result, but the number of fields listed after SELECT does not correspond to the ones specified in the task description.

- *The queried columns are incorrect.* The query is correct, and the number of columns is correct, but their names (such as alias names) or their order are incorrect.

- *The number of queried rows is incorrect.* The query is correct, it gives a result, but the number of rows returned is not the same as expected. The WHERE condition or HAVING contains an error, or the wrong query type is used.

- *The queried rows are incorrect.* The query is correct, it gives a result, but the result set contains at least 1 incorrect record. In this case, the portal shows

an example of the faulty record, thereby facilitating a successful modification of command.

- *The order of the queried lines is incorrect.* The query is correct, it gives results, the number and content of the returned rows is correct, but their order is not.

These error descriptons or messages can help the students to develop a successful solution. Through modifications and errors, students also learn the subtleties of creating SQL, which would be very difficult to discuss in a handbook or on an educational portal.

The other type of the grader is when students have to work with DDL and DML language elements. To test the DML elements, when specifying the task, the creator provides a preliminary script, the solution script and the control script. When solving the tasks, we use temporary databases, the elements of the temporary database are deleted when the database connection open to the user is closed. At the beginning of submitting the solution, we run the preliminary script, thus creating the objects of the temporary database.

After that, the administrator solution and the control script will be executed, which is typically an SQL statement, so we get the special set of records that we should also get at the end of the student solution. Therefore, we rerun the preliminary script, then the student solution, and the verification script. If the two result sets are equal, the solution is correct. For successful testing, it may also happen that the preliminary script already contains a DML instruction (there is something to delete, modify and thus check success). The testing of the DDL instructions is similar, only in this case the control script checks the information of the temporary schema, i.e. whether the table structure was successfully created, deleted or modified.

3. Curriculum

Our goal with the design and development of sqlsuli.hu was to give the teenage generation the opportunity to learn the basics of relational database management and SQL in a playful and effective way.

Using our website, students can learn how to apply different SQL statements such as Select, Update, Delete, etc. The curriculum focuses on the Select statement since students primarily have to know how to apply this one in the final examination. Through 24 chapters, students can learn to use Select statements, beyond basic use, through Join statements to the nested Select statements. The statements of DDL (Data Definition Language) and DML (Data Manipulation Language) are also introduced to the users of the portal. DML statements (Update, Delete from, Insert into and Insert into with Select) are presented through four chapters with practice exercises. In a separate chapter, DDL statements (Create table and Alter table) are also presented with a practical exercise.

The text of our curriculum contains imaginary dialogues between the authors of the curriculum and the student, provocative questions and comments, and also interesting examples. The modified quotes from Star Wars and Harry Potter, such as "There are always two of the Sith, now the tasks too" or "Curiosity is not a sin but we should exercise caution with our curiosity but not in this portal" accompany the entire curriculum. We have inserted emoticons and pictures related to the movie in each unit. Videos have been created for a better understanding of inner join clause.

4. Results

The aim of this paper is to present the main functionalities of a new website, called sqlsuli.hu. The portal is an online interactive platform that offers a free SQL course. The goal is to reach secondary school students who wish to learn SQL and help them to be successful in the final exam in computer science. The website starts by presuming no prior knowledge at all and lets students work through short exercises with gradually increased complexity. This website offers a SQL curriculum that uses Harry Potter and Star Wars databases.

In the website we developed a special grade system which enables completely individual and successful learning.

The site is open for anyone but currently used by the authors' students. We count on feedback from the authors' students, which makes it possible to correct any errors that may still exist in the portal, or makes changes to lessons, wording and assignments. Then the portal will be promoted.

References

[1] A. Abelló, M. E. Rodríguez, T. Urpí, X. Burgués, M. J. Casany, C. Martín, C. Quer: *LEARN-SQL: Automatic assessment of SQL based on IMS QTI specification*, in: 2008 Eighth IEEE International Conference on Advanced Learning Technologies, IEEE, 2008, pp. 592–593.

[2] T. Balla, S. Király: *A Discussion of Developing a Programming Education Portal*, Central-European Journal of New Technologies in Research, Education and Practice 2.2 (2020), pp. 1–14, doi: 10.36427/CEJNTREP.2.2.

[3] P. Garner, J. A. Mariani: *Learning SQL in steps*, Journal of Systemics, Cybernetics and Informatics 13.4 (2015), pp. 19–24.

[4] R. Kearns, S. Shead, A. Fekete: *A teaching system for SQL*, in: Proceedings of the 2nd Australasian conference on Computer science education, 1997, pp. 224–231.

[5] K. Lab: *SQL Murder Mystery*, 2019, url: https://mystery.knightlab.com/ (visited on 04/08/2023).

[6] A. Mitrovic: *A knowledge-based teaching system for SQL*, in: Proceedings of ED-MEDIA, vol. 98, 1998, pp. 1027–1032.

[7] S. Prabhu, S. Jaidka: *SQL and PL-SQL: Analysing teaching methods*, in: CITRENZ Conference, 2019.

[8] C. QUER, A. ABELLÓ GAMAZO, X. BURGUÉS ILLA, M. J. CASANY GUERRERO, C. MARTÍN ES-
COFET, M. E. RODRÍGUEZ GONZÁLEZ, Ó. ROMERO MORAL, A. URPÍ TUBELLA: *E-assessment
of relational database skills by means of LearnSQL*, in: EDULEARN17 proceedings: 9th In-
ternational Conference on Education and New Learning Technologies: Barcelona, Spain, 3-5
July, 2017, International Association of Technology, Education and Development (IATED),
2017, pp. 9443–9448.

[9] S. SADIQ, M. ORLOWSKA, W. SADIQ, J. LIN: *SQLator: an online SQL learning workbench*, in:
Proceedings of the 9th annual SIGCSE conference on Innovation and technology in computer
science education, 2004, pp. 223–227.

[10] H. AL-SHUAILY, K. RENAUD: *SQL patterns-a new approach for teaching SQL*, in: 8th HEA
Workshop on Teaching, Learning and Assessment of Databases, Abertay-Dundee, 2010,
pp. 29–40.

[11] S. XINOGALOS, M. SATRATZEMI: *The Use of Educational Games in Programming Assign-
ments: SQL Island as a Case Study*, Applied Sciences 12.13 (2022), p. 6563.