Teaching SQL in an On-line Learning Environment: Considering for Selecting a relational database

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Abstract
In today's business environment, students entering the workplace are expected to have problem-solving skills as well as an understanding of fundamental database concepts. Interns and new hires must be able to identify, extract and manipulate data that typically reside in a relational database. To meet this expectation, students are introduced to database concepts and SQL in a variety of courses. This paper discusses instructor considerations when selecting a database management system for teaching SQ on-line

Introduction
Today's students entering the workplace with degrees in business or interdisciplinary fields are expected to understand fundamental database concepts and have hands-on experience with Structured Query Language (SQL). Accordingly, students in a variety of disciplines are introduced to database concepts. Because of the diverse backgrounds of educators involved in teaching SQL, this paper will discuss broad considerations for selecting a relational database management system (RDBMS) and possible unintended "side-effects" on instructional time and resources in an on-line course.

SQL Across Disciplines
SQL is taught in courses in many disciplines; not just "database" courses. Very simply, SQL is the "language" of a relational database management system (RDBMS). It is the industry standard for communicating with databases that store an organization's operational data. One reason for the success of RDBMSs and their prevalence is that SQL acts as a standard for the most commonly used RDBMSs such as MySQL, Microsoft SQL Server, PostgreSQL, Oracle, Teradata, and IBM, (statista.com). As a result, from an educational perspective, SQL is found in online courses in degree and certifications programs in technology, business, and other types of disciplines. In the section that follows, examples of courses and interest in SQL are discussed.

SQL in Technology Disciplines
It is common to see database courses offered in technology related disciplines such as management information systems, database technologies and bioinformatics. For example, a database systems technology degree is a non-business degree with more than one database course requirement. The website, *computerscience.org,* shows an excerpt of the answer to the question, "What is a Database Management Degree?" as follows:

".... Students learn to use relational databases and software management systems and perform data analysis. ... Depending on the degree level, graduates ... can pursue roles like database administrator, computer and information systems manager, and data scientist. ..."

Although database courses are often associated with the skills needed by database or technology professionals, courses on database concepts and technologies are becoming more common place in other disciplines. An example of a degree with a technology focus is bioinformatics. To illustrate, in the description of the MS in Bioinformatics degree database courses on the Johns Hopkins Krieger School of Arts & Sciences web site, students can choose either, "Principles of Database Systems" or " Practical Computer Concepts for Bioinformatics" -- both courses include the topic of SQL. In the Master of Biotechnology: Bioinformatics at the University of Maryland Global Campus two database courses are required: Relational Database Systems and Advanced Relational/Object-Relational Database Systems. Both courses include the use of SQL (Anonymous, 2022). Similarly, The Master of Library and Information Science (MLIS) degree is another discipline where database concepts are introduced. The University of Denver's Online MLIS degree includes the course *LIS 4011 Information Access and Retrieval* that includes query languages such as SQL, (Anonymous, 2020). Syracuse University requires the course *IST 659: Data Administration Concepts in Database Administration* in their Master of Science in library and Information Science program. Its course description has the learning objective "*Solve problems by constructing database queries using SQL*" (Anonymous, 2022).

SQL in Non-Technology Disciplines
In non-technology disciplines such as business, database concepts are generally introduced in computer literacy or information technology courses. For example, SQL is typically introduced to business students one or more required courses in information technology. At Texas Southern University for example there are two courses, MIS 204, and MIS 304 in the "core" of the undergraduate business degree in management. In those courses, students learn introductory relational database concepts and SQL. These courses introduce students to SQL and database concepts to prepare them for advanced courses, graduate degrees and certificate programs that require the use of a RDBMS.

Undergraduate students who further their education draw upon and expand the database technology skills they obtained as undergraduates. In courses in master degree programs such as accounting, and data science students further their education in database concepts and SQL that they learned as undergraduates. For example, in the Department of Accountancy & Taxation at the Bauer College of Business at the University of Houston, the graduate course description of *Database Management Systems I* includes a description that describes the benefit of the course to a student's career (Anonymous 2022):

Figure 1

The Master of Science in Data Science at Texas A&M's Institute of Data Science*, the course Databases and Computational Tools Used in Big Data*, is a core course and *Database Systems* is an elective course (Anonymous 2022).

SQL in Interdisciplinary Programs

In interdisciplinary the fields of study related to data science, universities are offering courses such as those in business analytics, and marketing analytics. One common topic across many degree and certificate programs in analytics is SQL. A recent article *Decision Sciences Journal of Innovation Education* authors Johnson, Albizri and Jain (Johnson 2020) describe how universities are responding to the growing demand for business analytics (BA) practitioners by offering certificate programs as well as undergraduate and graduate level degrees. In their analysis of curriculum offerings, the authors identify concepts, skills, knowledge, and tools (CSKT) across three dimensions: data maturity, difficulty, and business impact. One common skill found across all these areas is SQL. See: *Concepts and tools in BA https://1drv.ms/u/s!ApzEj-mGACSagYgPupzjLbh_mUIHNw*.

SQL Across Analytics

The growing interest in business analytics can also be seen in Google search trends. The greatest search interest for the search terms "data analytics" or "business analytics" or "prescriptive analytics" was given a value of 100 at the time of this writing. Accordingly, the search interest has more than doubled compared to 6 years ago. See Figure 2: Research interest.
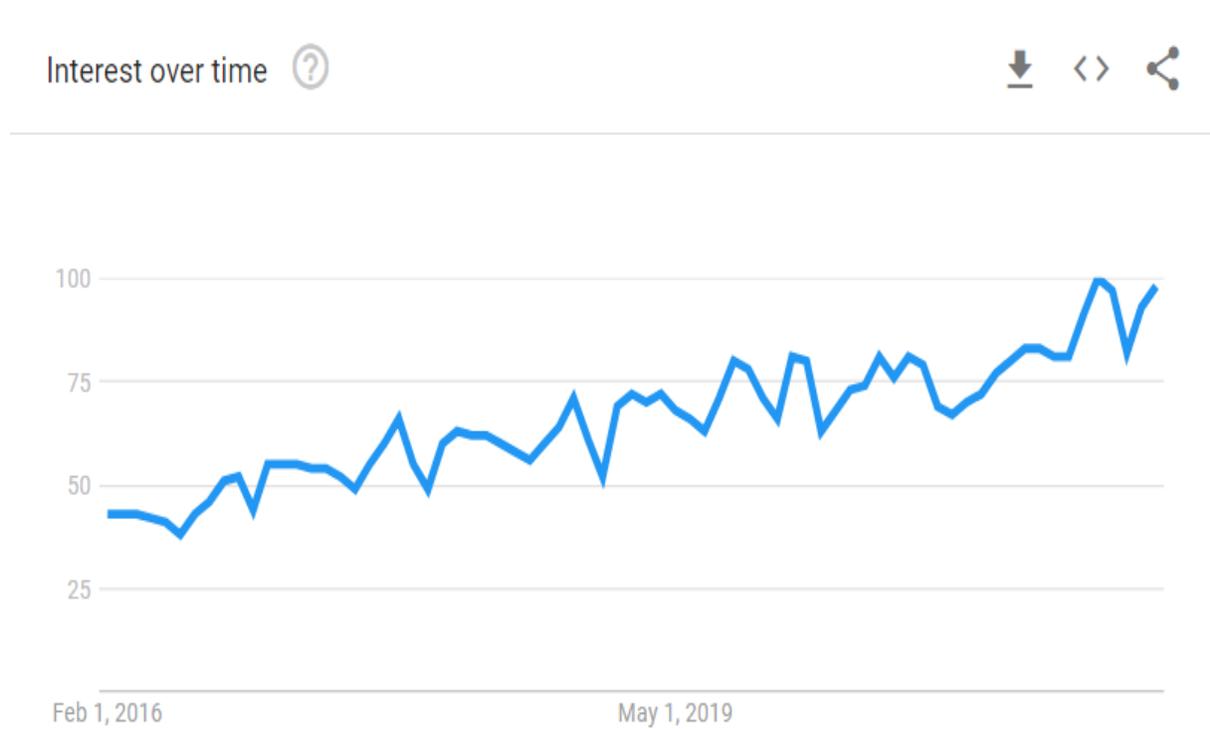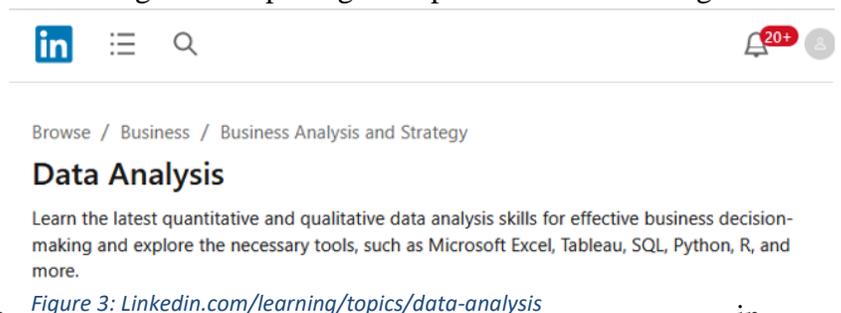
,
Figure 2: Search interest: "data analytics" or "business analytics" or "prescriptive analytics"

Benefits of SQL

A description of the benefit of knowing SQL in a business profession can be found in a Forbes article written by a financial analyst. The article gives compelling examples of how knowledge of SQL facilitated and enhanced the author's analytical capabilities, (Bereketli, 2017). Further evidence of the interest in SQL as a business skill can be found on LinkedIn Learning. Many universities have an agreement with linkedin.com so that students can access and complete any course for free. In a recent search Linkedin for Academics using the

Figure 3: Linkedin.com/learning/topics/data-analysis

term **SQL** over 5,000 courses were found. When browsing LinkedIn's business/data analysis courses, SQL is listed as a business tool under Business/Business Analysis and Strategy. Further evidence in the benefits of knowing SQL can be found on the web. For example, the website, learnsql.com, lists the types of jobs that require SQL skills. The list includes "SQL Data Analyst", "Business/Financial Data Analyst", "SQL Data Scientist" and "Data Modeler" (Anonymous 2022). Interestingly, these job titles seemingly do not imply a database or software application development focus. Instead, these jobs reflect that "working with databases is not limited to IT (Information Technology)." "Many experts in banking, accounting, and finance use SQL daily, creating reports and summaries." (learnsql.com). Furthermore, *learnsql.com* discusses the "Best Online SQL Courses for Finance and Economics Majors" summarized in the Massive Open Online Course (MOOC) course offerings table that follows (Babic, 2020):

MOOC	Courses	MOOC	Courses
Coursera	• Excel to MySQL • Analytic Techniques for Business Specialization • SQL for Data Science	DataCamp	• SQL for Business Analysts
Udemy	• Introduction to using SQL for Reporting • SQL & Power BI • SQL/MySQL • The Complete SQL Bootcamp • SQL Masterclass SQL for Data Analytics • The Complete Oracle SQL Certification Course	LearnSQL	• SQL Reporting • SQL Basics

Table 1: Best Online SQL Courses for Finance and Economics Majors

In summary, database concepts and SQL are introduced to students in a variety of academic disciplines and professions. The success of instructors teaching database concepts and SQL will in part be determined the course design and the successful integration a RDBMS for student use. This paper discusses considerations by instructors for selecting a relational database management system to facilitate the teaching of SQL in an on-line course.

Other Considerations
An instructor has a few obvious options when selecting a RDBMS. How these options can affect the success of a course is discussed in the section that follows.

Database Options
A locally installed database software on a student's computer is one option. There are lightweight versions of Oracle and SQL Server available for free. This option is not realistic for an online course because the instructor cannot "support" the local installation of the software on student computers; for many students downloading and successfully installing software are unfamiliar tasks. Furthermore, not all software is compatible with the all the different devices students use to access their on-line courses; a case against adopting Microsoft SQL Server is that it requires a Windows computer; it does not run on an Apple device or a Chrome Book. Requiring students to download and install database software on their personal devices leads to student dissatisfaction with the course due to hardware/software compatibility problems and/or a student's inexperience with software installation.

From the instructor's perspective, requiring students to install software is not an option because the instructor would need to devote course time and resources to installation requirements and instructions. And the instructor would need to be prepared to offer solutions to student problems. The instructor would have to be prepared to offer alternatives to students who cannot install the RDBMS for the course. Finally, most instructors are not skilled in trouble shooting problems as the result of hardware/software compatibility issues.

Even if all students are required to use Windows computers, instructors who use Microsoft Access for a RDBMS will quickly learn that Microsoft Access has limitations. Not only is Access only available for Windows computers, when it is installed, it does not default to the later version of the SQL Standard. As one textbook author states,

> *"Unfortunately, very few Microsoft Access users or organizations using Microsoft Access are likely to set the Microsoft Access SQL version to the SQL-92 option, and in this chapter, we assume that Microsoft Access is running in the default ANSI-89 SQL mode. One advantage of doing so is that it will help you understand the limitations of Microsoft Access ANSI-89 SQL and how to cope with them."* *(Kroenke, et al, 2021)*

The instructor needs to be aware of this limitation because the syntax of some SQL statements is dependent of the version of SQL supported by the RDBMS. This limitation will affect textbook selection and course resources provided by the instructor.

Another not so obvious option but related to locally installed software on students' computers is the option of installing a RDBMS on a remote server where students access the server over the internet using client software. For example, students could use Microsoft's Management Studio, the client software, to connect to a remote SQL Server. In some cases, if local drivers to support the client software are missing or not compliant, the instructor has to be prepared to help the student who experiences these types of problems. In the example that follows, Microsoft explains that a driver is not SQL-92 compliant.

> *"The ODBC Desktop Database Drivers and the underlying Microsoft Jet engine are not SQL-92 compliant. They support many features that have been defined in SQL-92. Some features supported in the driver are not supported in SQL-92."* (Anonymous 2021).

Figure 4: Driver compliance

As previously discussed, requiring students to install and configure software on their own devices is not a satisfactory option for students enrolled in an on-line course.

One option typically suited for an entire introductory database course, is the adoption of web-based interactive textbook with web-based access to a database that is integrated into the SQL assignments. For example, Cengage's MindTap product requires an instructor to adopt a textbook to access the database that is integrated into the MindTap course. Because the database is not a stand-alone product; this option is not acceptable for a course say in finance that touches on database concepts and is mostly concerned with the use of SQL to extract data from a database.

A free cloud-based database management system accessed over the Internet by users with a web-browser is a good option for an on-line course. In most cases, students can easily create accounts

and learn to use the interface with some guidance by the instructor. Examples of cloud-based DBMSs that are free and easy to use are Build Online Database Apps - Low-Code Platform | Caspio (caspio.com), Oracle Live SQL (livesql.oracle.com) and Oracle APEX (apex.oracle.com).

Other options for free cloud-based database management system include SQL Azure, with the Azure platform, Oracle Cloud or Amazon Web Services. These enterprise platforms as solutions for introducing relational database concepts and SQL are overkill and often require users to set-up accounts with a payment method to secure payment after the initial free period. This is not a satisfactory option for students because of the payment method requirement.

There are other considerations in selecting a selecting a cloud-based database platform for teaching SQL. The choice of the RDBMS will affect instruction, students' hands-on experiences and will influence the choice of textbooks and supporting materials for the course.

In short, the instructor in an on-line course that uses a cloud-based RDBMS does not have to be concerned with devoting instructional time to informing students how to connect to a remote or locally installed database management system. In turn, students do not have to be concerned with compliant or other issues associated with locally installed software needed to connect to a remote or locally installed database. Therefore, when an instructor selects a Cloud based RDBMS, the instructor can focus on the version of SQL supported by the database management system and how it will influence textbook selection, SQL instruction and selection of teaching supplements and resources.

SQL Options

Every RDBMS has is its own version of SQL. As of this writing, the latest version as of Feb. 2022 is ISO/IEC 9075:2016, also known as SQL:2016." (postgresql.org) Details of the latest SQL standard can be found on the *iso.org* website. (Anonymous 2016) Because SQL is the standard database language, the users of one RDBMS can easily work with another. However, every RDBMS has its own unique version of SQL with proprietary additions on top of the SQL standard. Here is an example to illustrate the subtle differences in SQL. To limit the number of rows returned by a query, it is well-known that SQL syntax for each of the following RDBMSs are different: Server/MS Access, MySQL, and Oracle. See SQL SELECT TOP, LIMIT, FETCH FIRST ROWS ONLY, ROWNUM (w3schools.com).

Many database software providers publish their compliance to Core SQL ANSI and ISO SQL standards. These public resources are especially useful when instructors use examples from textbooks or other resources and the examples produce errors. The instructor may need to consult compliance documentation to determine the source of the error if a student encounters the error. The following graphic shows that Oracle does not support the E0210 standard for naming the function for extracting a substring with a specified length from a starting location in an input string. Instead of using the E021-06 standard's specification for the function name as *SUBSTRING(),* Oracle names the function *SUBSTR()* (Anonymous 2022).

Oracle has equivalent functionality for these subfeatures:

- E021-04, CHARACTER_LENGTH function: use LENGTH function instead
- E021-05, OCTET_LENGTH function: use LENGTHB function instead
- E021-06, SUBSTRING function: use SUBSTR function instead
- E021-11, POSITION function: use INSTR function instead

Figure 5: E021: Oracle

Continuing with this example, the syntax (shown below) of the E021-06 standard for the SUBSTRING function includes the reserve words, *FROM, FOR* and *USING* that are not used in Oracle or Microsoft's T-SQL.

E021-06: The Standard

SUBSTRING (<character value expression> **FROM** <start position>
 [**FOR** <string length>] [**USING** <char length units>])

Oracle's SUBSTR()
SUBSTR (<character value expression>, <start position>, <string length>)

Microsoft's SUBSTRING()
SUBSTRING (<character value expression>, <start position>, <string length>)

SUBSTRING (Transact-SQL)

Returns part of a character, binary, text, or image expression. For more information about the valid SQL Server data types that can be used with this function, see Data Types (Transact-SQL).

Transact-SQL Syntax Conventions

Syntax

```
                                                        Copy
SUBSTRING ( value_expression , start_expression , length_expression )
```

Figure 6: SUBSTRING (Transact-SQL)

In summary, instructors need to be aware of the version of SQL supported by the database management system selected for teaching or using SQL. Although, SQL is the standard database language, the textbooks and SQL instructional resources selected by the instructor must be reviewed in order to minimize problems that students may encounter when using the database management system. There should be no mismatch between the version of SQL discussed in the textbook and the version of SQL supported by the RDBMS.

Textbook options
Some instructors may choose to first teach standard SQL before introducing SQL features specific

to the RDBMS. Other instructors may choose to teach only standard SQL with the understanding some RDBMSs or related software do not fully adhere to the latest SQL standard. In either case, the course instructor must carefully review and prepare the course content and instructional materials for SQL consistency.

Conclusion

This paper discussed instructor considerations when selecting a database management system for teaching SQL on-line to students in diverse disciplines. In particular, database options and the version of SQL supported by the database will have an effect on instructional material such as textbook selection and how standard SQL or extended features of SQL will be taught.

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