A Review on Tools for Teaching Database Systems Online

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Abstract: *Database Systems is a core discipline in undergraduate Computer Science and Engineering programs. The discipline includes learning a large range of different theoretical and practical topics such as data modeling, database design or SQL. Studies have identified that students find the topic complex and have difficulties in learning such topics in traditional face-to-face setting. This article presents state-of-the-art tools that are found in the literature and how they could be used to overcome some of the existing difficulties.*

Keywords: *Online Learning, Learning Database Systems, Database Tools*

I.   Introduction

Database Systems are critical as they allow organizations to store and process data in optimized ways. Their importance will continue to increase as data is, for many organizations, the most valuable asset and unique value proposition. Therefore we observe an increasing demand for highly qualified experts in database areas. This is why Database Systems is a core discipline in any undergraduate and graduate Computer Science and Engineering programs [1]. Douglas and Vyver [2] reinforce the importance of databases for students and professionals by stating that the Database Management Systems (DBMS) course is pivotal in determining the success of its graduates.

Courses on Database Systems introduce data and information management and traditionally focus on learning the database design process, i.e. analyzing abstract problems and building conceptual, logical and physical data models [3].

Database design is the well-defined process of converting a given abstract problem into an optimized database. It consists of at least the following steps:
1) Identify and capture organization and project requirements
2) Model requirements using conceptual model techniques
3) Convert conceptual models into relational models, using normalization techniques to ensure structural characteristics
4) Implement database using an industry Database Management System.

In [4], authors describe the curriculum guidelines for undergraduate degree programs in information systems by the Association for Computing Machinery (ACM) and the Association for Information Systems. Regarding the objectives and key topics for Database System courses, authors suggests that the curriculum should, besides database design, also include key topics on database administration, data quality and security. The course should also include a strong practical component where students develop full database applications that allow them to interact and understand the importance of Database Management Systems.

The course on Database Systems is very comprehensive, involving large theoretical knowledge, and, at the same time, professional knowledge about the industry as well as practical problem solving. Although being a core discipline in Information Systems programs, multiple studies show that students often find the course difficult to understand [5, 6, 7].

Online and blended learning are alternative methods to traditional face-to-face education that are receiving growing interest. They are possible due to existing internet technologies that allow

instructors to deliver content online, as well as, students to communicate with their instructors and other peers [8]. Online tools allow classes and communication to occur both synchronous and asynchronous independent of physical location [9]. Higher education organizations are aware of the opportunities and benefits and are increasingly adopting more flexible teaching modes [10, 11, 12]. Schmidt et al. [12] show that that, when given the choice, students often opt to enroll in different modes in each course. Moving education online allows reaching a broader audience, giving the opportunity to all students, including those who live in other countries, isolated areas or are not able to physically move, to access high quality courses from top education organizations. More recently, schools around the globe were forced to teach online due to confinement imposed by the COVID-19 pandemics.

However, moving towards fully online and blended teaching modes raises multiple pedagogical questions. While many face-to-face methods and materials can be adapted for the online context, this is often not the best practice and does not fully exploit the benefits of online teaching tools [13, 14, 15]. Designing an online course implies rethinking the courses' content program, tools, materials, assessment methodologies as well as the expected changes in the role of students and teachers. Challenges in online teaching include student motivation, participation and engagement, difficulties in the use of technology by both students and teachers, adoption of new assessment methodology, shift of the teaching methodology and the instructor's role from an initiator of knowledge to a facilitator perspective [12, 14, 16].

In this article, we review the existing challenges in traditional face-to-face teaching of database systems. We discuss the benefits and the opportunities of moving towards fully online and blended learning in general education and review database teaching tools that be found in the literature. We discuss how the teaching methodology could benefit from some of these tools and how they could be used to tackle the existing challenges of teaching database system courses.

II.   Challenges in Learning Database Systems

The Database Systems discipline is perceived by students as a difficult to learn [17, 18, 19, 20]. Murray and Guimaraes in [6] and Connolly and Begg in [7] state that database design is challenging to teach and to learn due to its abstract nature. The first proposes addressing this problem through the use of supplemental material while the latter suggests using a constructivist learning environment. In [21], the authors state that the students felt that learning programming language was abstract and difficult to learn resulting in the loss of interest and confidence in programming and they propose focusing on individual learning and micro-lecture. The work in [22] states that students are passive and lack learning initiative in a teachers' dominated process. The authors state that students are not able to associate the course with other courses and that the traditional assessment methods are inadequate. In [23], Rashid and AlRadhy mention four issues in teaching and learning which seem related to the traditional "teacher centered" method: the absence of teaching determination, the contradiction of content and theory, traditional teaching methods, and missing assessment of practical skills.
Students seem to have difficulty in understanding the interest of SQL [24] and database normalization [25]. In [26], authors refer the lack of innovation and creativity.

Fang et. al. [5] conducted a survey in multiple universities in China. The authors describe multiple problems in teaching databases: more attention given to teaching instead of practice, students are bombarded with information in the teaching process and fail to develop learning initiative, experiment time is short and content is very simple and different from real engineering practice and industry standards.

III.   Tools for Learning Database Systems

In order to address the lack of interest and motivation, Ying [21] proposes teaching databases through the use of Micro-Lectures - short videos of 10 minutes explaining key

concepts in a simplified manner. The author states that students can only concentrate for periods of 5 to 10 minutes. Tools to produce the micro-lecture are suggested: 1) recording can be done using a traditional camera and editing software to produce the 10-minutes clip; 2) record using smartphone camera; 3) use of micro-lecture production software such as EduCreations or ShowMe; 4) Screen recording software such as Camtasia studio or Screen Recorder.

For addressing lack of students' initiative and passiveness, [5] proposes using blended learning and flipped classroom - learners conduct learning autonomously and the classroom becomes a place for teachers to interact with students and mainly used to answer questions and discussions.

In order to bridge the gap between theory and practice in DBMS, Cvetanovic et. al [27] developed ADVICE, a web-based education system, providing a series of exercises about conceptual and logical modeling, SQL, formal query languages, and normalization. To solve the exercises, students must use and access real databases and receive feedback about the solution.

The need for better feedback and more engaging tools is tackled by Mitrovic and Suraweera who propose KERMIT [28], a constraint-based tutor that teaches database design. KERMIT was applied as an EER-Tutor and provides an Intelligent Tutoring Systems which checked whether the students' database scheme was correct by matching it with the ideal constraints and solutions and providing effective feedback to students. TableERD [29] is another tool for learning database design which assists students in developing ER Diagrams. The tool is able to automatically generate the corresponding SQL code.

Want et. al. proposes MeTube [30], a project where students should build their own copies of YouTube. The authors state that using well-known YouTube as base project will increase interest from students and allow them to work on a real-world project. To bring engagement and interest to students.

SQL-LES [31] is an SQL Learning and Evaluation System which provides components for teaching and learning database design, SQL, PL/SQL and implementation of database projects. It provides a question bank covering all areas of SQL questions and answers.

Martinez proposes adapting the classes content to students' weaknesses through Just-In-Time Teaching [32]. Students are given a reading test the day before the class. The instructor adapts the next day class according to detected weaknesses.

IV. Conclusion

Databases are core for storing information of most applications and businesses. In a data-oriented era database are increasingly gaining importance and the qualified experts are difficult to find. We reviewed the literature and presented a list of problems related to traditional face-to-face teaching of database system courses. Furthermore, we found multiple examples in the literature of existing online learning tools which could help addressing some of the known issues.

Problems in teaching database system courses are well described in the literature and multiple proposals seem to already exist. This article summarizes both problems and possible solutions aiming at helping the development of high-quality online database courses. In particular, this article described online tools which can be used to address the following identified problems: students' lack of interest, lack of initiative, bridging the gap between theory and practice,

It is crucial that the database teaching community is aware of existing difficulties and existing tools in order to better adapt to students and market needs. Adopting some of the tools will result in higher satisfaction of instructors and learners as well as more market fit database professionals. Thus, tools that may improve the learning for students in a Database Systems course are important to not only the faculty and students but to their employers as well.

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