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A review of increasing teaching and learning database subjects in computer science

Una revisión de aumentos de la base de datos de enseñanza y aprendizaje en ciencias de la computación

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ABSTRACT:

Database is a course dealing with analyzing and managing various database management systems, mastering the design, develoing and maintenance of database application systems. Generally, the difficulties of computer science students in learning databases would be indicated by the literatures. The method of this research was reviewing journal articles related to teaching and learning database courses. This research aimed to report efforts to overcome the lack and the teaching approach applied in improving learning database subjects such as Blended Learning approach, constructivism approach, Flipped Classroom approach, Cognitive Learning Theory (CLT) approach, active learning techniques, computer-based instruction and others.

Keywords: Database, Teaching and Learning Database, Problems in Database.

RESUMEN:

Base de datos es una materia que trata sobre el análisis y la administración de varios sistemas de administración de bases de datos, el dominio del diseño, el desarrollo y el mantenimiento de los sistemas de aplicación de bases de datos. En general, las dificultades de los estudiantes de ciencias de la computación en el aprendizaje de bases de datos son indicadas por las literaturas. El método de esta investigación fue revisar artículos de revistas relacionados con la enseñanza y el aprendizaje de cursos de bases de datos. Esta investigación tuvo como objetivo informar sobre los esfuerzos para superar la falta y el enfoque de enseñanza aplicado para mejorar los temas de la base de datos de aprendizaje, como el enfoque de aprendizaje combinado, el enfoque del constructivismo, el enfoque de aula invertida, el enfoque de la teoría del aprendizaje cognitivo (CLT), las técnicas de aprendizaje activo, la instrucción por computadora y otros.

Palabras clave: Base de datos, Base de datos de enseñanza y aprendizaje, Problemas en la base de datos.

1. Introduction

Comprehensive growth of technology affects all aspects of life whether it is in economics, politics, culture, art field and even in the world of education. Technological progress is something we cannot avoid in this life because it will extend according to science progress. Every innovation is created to provide positive benefits for human life, to present many conveniences, and as a new way of human activities. To be specific, the innovation produced in the last decade have led to many benefits in the field of information technology (Zvezdan & Boško, 2016).

The internet development in the education field produces a distance learning system(Cavus, 2015), by which a student no longer needs to go to school like a formal school. The student only needs to set the time to meet the lecturer or teacher via a computer monitor. The students do need to go to the library to gain knowledge. They can sit in front of the monitor and the knowledge is already available(Puspitasari & Oetoyo, 2018). Even a lecturer will easily find instructional materials that are in accordance with their fields. Moreover, a student can explore the knowledge through their ability in finding additional information outside of what is taught by teachers(Dogruer, et.al., 2011). For example, they can utilize an android device with Adobe Flash CS6 tools to design dynamic and static electricity learning media. Dynamic and static electricity learning is difficult for students; it is abstract when students learn it traditionally. Through the media designed by using an Android device, students can easily understand the materials anytime and anywhere (Zaus, et. al., 2018). In addition, the application of the *Electric Software Kumanda Teknikleri Simulatoru* (EKTS) in the subjects of electromagnetic control at grade XII TITL Bapituh Vocational School 1 (SMKN 1 Bapituh) resulted in an increase of learning outcomes after using EKTS software (Effendi, et. al., 2017). As a consequence, changes in teachers' and students' mindset and creativity could develop rapidly, so that a more contextual thinking horizon is materialized and it is easier to digest the information obtained. Even within the education scope, it is time to form an information network which utilizes information technology in order to create a network connected between schools as the exchange of data and information quickly, accurately and certainly cheap in all fields. The dissemination of ideas and learning methods in a more appropriate learning process will also reach the remote areas more easily. Moreover, researche on the use of social media to build e-learning systems in Vocational Schools by utilizing Facebook, Google Drive, and Google Form (Setiawan, et. al., 2018).

Database system helps organizations to store data, then processes and uses them optimally. The database system recently becomes organization's needs. One of the examples is the design of data processing applications for goods transportation licenses at the transportation agency in Limapuluh District (Nozomi & Hamzah, 2018). This application system uses PHP and MYSQL programming language. All data entries are processed in a database. Those diverse data will be administered more easily and quickly in a well-organized system. The accuracy of the data is required so that no irregularities and errors found in the reports. Then data security is more assured by using a database. As a result, the desired information can be recognized more quickly and accurately by the intended parties. Moreover, this system can minimize the time in the process of making reports, and the reports are produced more effectively and efficiently (Nozomi & Hamzah, 2018). After that, in designing inventory management systems in the computer laboratory of School of Business Pelita Indonesia, Android-based Near Field Communication technology was implemented to keep inventory data in an online database. In addition, NFC tags can be accessed easily by using an Android Smartphone which has NFC devices and also via the Web connected to the internet (Hamzah & Purwati, 2017).

Database is a compulsory subject that computer science students have to take at the beginning of the semester (Shang, 2016). Most courses in the database system do not only cover lecture classes, but also work practices by using the education system (Cvetanovic et. al., 2011). The database course is one of the core curricula for computer majors, which is very comprehensive, involves a lot of theoretical knowledge and at the same time and professional knowledge about relative industry, as well as is very practical. Understanding relevant concepts, theories, and regulations and skilled operational capabilities comes from

practice. Handling agile database management and operation is one of the skills required for students majoring in computers (Zhuoyi, et. al., 2012).

In creating its own database system, a settled design is necessary in order to make the designed database system run well. A well-designed database system will support the operational system of the running organization. Errors in database design will result in a bad database structure so there will be redundancies and inconsistencies in the stored data. This kind of data will make it difficult for the organization to retrieve the information needed so that it might cause the organization choose the wrong decision and will bring the organization to a fatal failure (Folorunso & Akinwale, 2010).

2. Methodology

This review research was conducted by collecting international journal articles through journal databases such as: ERIC, Science direct, Google Scholar, IEEE, emeraldinsight, and others. There were 101 articles found to have keywords such as *"Database, Database Course, Teaching and Learning Database, SQL, DBMS"*. After reviewing 101 journal articles related to teaching and learning database, 35 journal articles were selected due to their relevance to this study.

3. Result and Discussion

3.1. Students' Difficulties in Learning Database Subject

For years, many students have difficulties in learning database, and many researchers have written about this problem. A quote in a survey of several universities in China found that there were several problems in teaching "Database Principles" (Fang, A., et. al. 2017):

1. The phenomenon of "paying more attention to teaching theory, not its practice" still existed in teaching, which directed students to understand only the basic principles and lack of practical practice skills after completion of the course (Rashid, T. 2015, Mason, R. 2013).
2. In the teaching method, despite the introduction of various multimedia technologies, traditional "*cramming*" model still existed. Because of the change from "*chalk + blackboard*" to "*computer + screen projection*", students got bored with information bombing throughout the teaching process, completely failing to develop their learning initiatives.
3. In teaching "database principles", most practices were very simple, multiple designs and comprehensive practices. In addition, the time was short (Saeed, S. et. al. 2011), the contents were relatively simple and very different from the real-world practice environment (Dunn, D. 2005).

Meanwhile, some studies support the statement that database learning is difficult to understand and they also state that it is very difficult for students to understand by learning through traditional teaching because they feel that programming language is abstract (Murray & Guimaraes, 2009, Connolly & Begg, 2007) and it is difficult to understand. As a result, they lose their interest and trust in programming (Ying, 2016). In addition, in traditional teaching, students are considered as machines to receive and copy knowledge. The teacher ignores individual differences and psychological needs. Consequently, students become depressed because they are passive. The "teacher centered" and "classroom centered" in traditional methods are not suitable for this course (Rashid & AlRadhy, 2014, Liu, 2012, Domínguez & Jaime, 2010). Since they lack the ability to develop students' innovation and the power of active learning. They lack of growing innovation talent and creativity(Wang & Chen, 2014).

Cases in teaching are limited to library management systems and student management systems that make students passive. It causes students' enthusiasm becomes low and not innovative (Wang & Ma, 2017, Abid, et. al., 2015). The conventional database system has a high failure rate. Employer surveys indicate that graduates lack of expertises in database design, setup and administration. Understanding the SQL structure and the ability to build SQL queries are considered integral in database learning (Mason, et. al. 2016) and has become a major focus in course materials and activities. However, students performed

poorly in the SQL section in the semester final exam. Students also demonstrated insufficient understanding of the reasons they were asked to learn SQL (Folorunso & Akinwale, 2010). In tertiary institutions, some students found it difficult to study database design theory, especially database normalization (Poščić, et. al., 2012). Another difficulty was how to make the project in this database subject to market needs (Podeschi, 2016).

3.2. Methods for Improving Database Teaching and Learning

Due to the problems faced by students who study databases, various methods for improving teaching and learning were designed and developed. Table 1 lists articles that were researched in an effort to improve teaching and learning database.

Table 1
Methods for Improving Teaching
and Learning Databases

Researchers	Methods
Ying, F. (2016)	Micro Lecture
Fang, A. et. al (2017)	Blended Learning dan Flipped Classroom
Zhuoyi, C. (2012)	Constructivism
Wang, N., & Ma, C. (2017)	Blended Learning
Liu, X. (2012)	Project Guide dan Task Driven
Cvetanovic, M. (2011)	Educational System Based on Web, ADVICE
Rashid, T. (2015).	Kombinasi teori dan praktek
Mason, R. (2016)	Cognitive Load Theory(CLT)
Podeschi, RJ. (2016)	Project Based Learning
Baugh, J. (2015)	Real World Approach
Abid, A. (2015)	(Theory + Practice + Project) approach
Bunch, J. (2009)	Goal-based scenarios
Saeed, S. (2011)	Project Based Approach
Mitrovic, A., & Suraweera, P. (2015)	KERMIT-Intelligent Tutoring Systems (ITS)
Sok, S., & Scharff, C. (2006)	TabletERD
Wang, J. et. al. (2009)	MeTube
Hoque, A. et. al. (2014)	SQL Learning and Evaluation System (SQL-LES)
Lu, J. et. al. (2012)	Project-Driven Teaching Model

Shebaro, B. (2018)	Active Learning Strategies
Martinez, A. (2012)	Teknik Just-In-Time Teaching (JiTT)

Based on the table, it can be explained that the teaching method of Micro Lecture can meet the demands of E-learning, M-Learning, Blended learning, and fragmentation learning. Video as the main carrier, note the whole teaching and learning activities process (Ying, 2016). *Blended Learning* and *Flipped Classroom (multidimensional blended flipped teaching model)* were utilized for students' Computational Thinking abilities (a series of thinking activities that encompass computer science with the basic concepts of computer science, such as problem solving, system design, and understanding human behavior)(Fang, et. al. 2017). Constructivism means that learning is not obtained through the provision of teachers, but through the construction of meaning and this method is also Student centered in a course (Zhuoyi, et. al. 2012). Researchers then constructed a "project guide", namely Lecturers Assist students to approach the project, explore the students independently and interactive collaboration trains students to analyze, solve and deal with the problem (Liu, X. 2012). A web-based education system, known as ADVICE, helps students to bridge the gap between the theory and practice of the database management system (DBMS). The use of ADVICE was presented through a series of laboratory exercises developed to teach students' conceptual and logical modeling, SQL, formal query languages, and normalization. While doing the exercises, students use the system to access real databases, and the system gives them input about the solution. From an instructor's perspective, this system allows easy management of training and continuous monitoring of progress (Cvetanovic, 2011).

Meanwhile, in increasing students' understanding of learning database courses by upgrading teaching content, it is essential to renovate teaching methods and excellent assessment methods to work with theory and practice simultaneously (Rashid, 2015). Databases and their applications are courses in which theory and practice must be combined. Students can only memorize important theoretical knowledge if there are only theories that test them as evaluation methods. It obviously shows that almost all students believe that the importance of updating teaching methods can be completed through project use, strengthening exercises, and the use of case studies (Rashid & AlRadhy, 2014). CLT is based on a model of human cognitive architecture information processing. Specifically, CLT focuses on the concept of long-term memory and working memory and the interaction between the two. Application of Cognitive Load Theory (CLT) to the redesign of the Introduction Base System course historically has low student satisfaction and relatively high student failure rates. The former students also showed a lack of understanding of some key concepts as evidenced by performance in the exam and also student feedback. This course is considered very technical and challenging for student profiles, especially Informatics Engineering students based at business schools and in the second year of their university studies (Mason, et. al., 2016).

It is very important to integrate real-world projects into classes in database learning. Real-world projects place students in situations where real risk is involved. In addition, real-world projects emphasize on doing their expertise as professional Information Science, because they will start their first work (Podeschi, 2016). The "Real World Approach" is applied through the partnership of universities and companies. Students are given as much real-world experience as possible. Therefore, a lot of time is demanded in the design work of simulating real-world problems as well as a detailed design of individual student semester projects. If the course material is designed to be more attractive, students are more likely to be encouraged to learn it. Real-world projects allow students to "learn better through specific domains of their interest" and "see the practical value of what they learn". This method is able to bring a lot of personal experience as a database consultant to the class every day. Students benefit from discussions of real meetings with real users and real problems (Baugh, 2015).

Through the integration of theories, practices and projects in studying databases (Abid, et. al., 2015) and the Goal-based scenarios approach, these findings focused on using goal-based scenarios in teaching basic database concepts, but it must be a direct task to

implement this technique successfully on various topics of information system with similar results. Problem-centered instruction provided an effective approach to teaching the design process inherent in the task of database professionals to translate business problems into relational databases and success with technology-based tools that uses scaffolding to support students learning basic programming concepts.

Based on questionnaire surveys conducted, Project Based Approach was very effective in teaching databases. The feedback from students clearly demonstrated that they enjoyed the teaching process and got new knowledge and skills accordingly. Feedback also illustrated the effectiveness of teaching methods. Most students performed well in examinations as well (Saeed, et. al., 2011).

KERMIT is a constraint-based tutor that teaches database design. KERMIT was applied as an EER-Tutor, and it expanded its instructional domain. Several evaluation studies conducted with KERMIT and EER-Tutor showed that they were effective Intelligent Tutoring Systems (ITS). The database design tutors efficiently handled large solution spaces by setting limits that captured the status of equivalent solutions, and using ideal solutions to capture semantic problems. Instead of requiring a problem solver, ITS checked whether the student database scheme was correct by matching it with the ideal constraints and solutions. Another contribution from those studies was a guide to develop an effective feedback to students (Mitrovic & Suraweera, 2015).

After that, tabletERD is an open source CASE tool which is based on Tablet PC technology. TabletERD can be used on ordinary PCs with drag and drop features. Users can pull ERD components: entity type (rectangle) and relationship type (line between entity and / or relationship type). When the relationship type is recognized, diamonds are added to ERD. Entity attributes and types of relationships: property attributes such as names and types are included from the drop-down menu (Sok & Scharff, 2006). Next is the development of learning using MeTube. MeTube achieves the goal with real-world problems where students are accustomed to getting to know it and their great interest due to the creative nature and level of artistic expression that is rarely found in traditional database courses. The MeTube system is a modified version of the popular YouTube system (http://www.youtube.com) (Wang, et. al., 2009).

This model was applied to the famous SQL Learning and Evaluation System (SQL-LES). The complexity value of the existing calculations was compared to the complexity value in the SQL-LES question bank set by SQL experts. It was found that in many cases, the existing model produced the same complexity values as SQL-LES. The application of this model reduces the instructor's workload in SQL-LES (Hoque, et. al., 2014).

In addition, Project-Driven Teaching Models were also developed in teaching database in which this model was a project-based teaching model. Students are at the center of the learning process, engaging in long-term topic studies, connecting their learning to the real world, collaborating, participating in decision making, using various assessments throughout the project (Liu, 2012, Lu, et. al., 2012) and active learning strategy methods to overcome existing challenges. This paper presented teaching strategies for introductory database courses that promoted the use of case studies, student teams, and the role of students in database education inspired by active learning pedagogies (Shebaro, 2018).

Just-In-Time Teaching (JiTT) technique was implemented in undergraduate database courses for computer science major for two semesters. JiTT was conducted by giving students a reading assignment and asking them to complete a web-based reading test the day before class, so that the teacher could detect weaknesses in students' understanding of the material and adjust the lesson plan in time for the next day class. Based on surveys and the examinations and students’ scores, it revealed a significant increase in student interest in courses and material learning (Martinez, 2012).

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4. Conclusion

Many students who studied by using global or conventional techniques got difficulties in learning the basis or concept of database. They assert that database learning is abstract and

very difficult to understand. For this reason, many research were conducted on the development and application of various methods to increase students' understanding in learning database courses. Most methods were developed by implementing computer technology, multimedia, mobile and web-based in order to provide interactivity, visualization, effectiveness and essence in getting teaching materials, tasks, database learning resources and student feedback. Those methods improved students' performance and developed skills among students. Feedback and comments from students were positive and greatly encouraged students' interest in understanding database learning even deeper.

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